U.S. Department
of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Type Certification—Powered-lift | **Date:** DRAFT | **AC No:** 21.17-4
Initiated By: AIR-600

1 PURPOSE.

1.1 This advisory circular (AC) provides guidance for the type, production, and airworthiness certification of powered-lift. This AC also designates the criteria in appendix A as an acceptable means, but not the only means, of showing compliance with title 14 of the Code of Federal Regulations (14 CFR) 21.17(b) for Federal Aviation Administration (FAA) type certification of certain powered-lift.

1.2 The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide information to the public regarding existing requirements under the law or agency policies. Conformity with this guidance is voluntary only and nonconformity will not affect rights and obligations under existing statues and regulations.

2 RELATED MATERIAL.

2.1 Title 14, Code of Federal Regulations.

The full text of these regulations is available at https://www.ecfr.gov.

- Part 1, *Definitions and Abbreviations*.
- Part 21, *Certification Procedures for Products and Articles*.
- Part 23, *Airworthiness Standards: Normal Category Airplanes*.
- Part 25, *Airworthiness Standards: Transport Category Airplanes.*
- Part 27, *Airworthiness Standards: Normal Category Rotorcraft*.
- Part 29, *Airworthiness Standards: Transport Category Rotorcraft.*

- Part 33, *Airworthiness Standards: Aircraft Engines*.
- Part 35, *Airworthiness Standards: Propellers*.
- Part 36, *Noise Standards: Aircraft Type and Airworthiness Certification*.
- Part 39, *Airworthiness Directives*.
- Part 43, *Maintenance, Preventive Maintenance, Rebuilding, and Alteration*.
- Part 45, *Identification and Registration Marking*.
- Part 91, *General Operating and Flight Rules*.
- Part 145, *Repair Stations*.
- Part 183, *Representatives of the Administrator*.

2.2 **FAA Publications.**

The following publications are related to the guidance in this AC. You should refer to the latest version for guidance, which is available on the Dynamic Regulatory System (DRS) website at https://drs.faa.gov/browse.

- Order 8110.4, *Type Certification.*
- Order 8110.48, *How to Establish the Certification Basis for Changed Aeronautical Products.*
- Order 8110.54, *Instructions for Continued Airworthiness Responsibilities, Requirements, and Contents*
- Order 8110.112, *Standardized Procedures for Usage of Issue Papers and Development of Equivalent Levels of Safety Memorandums.*
- Order 8120.22, *Production Approval Procedures.*
- Order 8120.23, *Certificate Management of Production Approval Holders.*
- Order 8130.2, *Airworthiness Certification of Aircraft.*
- AC 21-43, *Production Under 14 CFR Part 21, Subparts F, G, K, and O.*
- AC 21.101-1, *Establishing the Certification Basis of Changed Aeronautical Products.*
- AC 45-2, *Identification and Registration Marking.*
- PS-AIR-21.17-01, *Safety Continuum for Powered-lift.*

3 BACKGROUND.

3.1 Part 21 provides procedures for the type certification and airworthiness certification of special classes of aircraft. Special classes of aircraft include gliders and powered gliders, airships, powered-lift, and other kinds of aircraft, which would be eligible for a standard airworthiness certificate but for which no airworthiness standards have as yet been established as a separate part of 14 CFR chapter I, subchapter C. Airworthiness standards for these special classes of aircraft are the portions of the requirements in parts 23, 25, 27, 29, 31, 33, and 35 of 14 CFR found by the FAA to be appropriate and applicable to the specific type design and any other airworthiness criteria found by the FAA to provide an equivalent level of safety to the existing standards.

3.2 Powered-lift is defined in part 1 as a heavier-than-air aircraft capable of vertical takeoff, vertical landing, and low speed flight that depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on nonrotating airfoil(s) for lift during horizontal flight. Powered-lift have characteristics of both an airplane and a rotorcraft. They have the capability to function as a rotorcraft for takeoff and landing and as an airplane during cruise flight. This combination of lift capabilities creates the potential for increased speeds and duration, compared to rotorcraft, during the enroute portion of the flight.

3.3 Recent applications for the type certification of powered-lift have proposed passenger seating configurations of six or less, weighing 12,500 pounds or less, and utilizing battery-powered electric engines for propulsion. For each of these projects, the FAA has published the proposed airworthiness criteria, along with an explanation of its equivalency determination, in the Federal Register for public notice and comment.

3.4 The FAA used its experience with those recent powered-lift applications to develop the criteria in appendix A. This AC establishes a more efficient path in designating the type certification basis for certain powered-lift projects, as the FAA will not need to announce the criteria for each project in the Federal Register for notice and comment for those designs that use the criteria in this AC with no additions or changes.

4 DISCUSSION.

4.1 Appendix A of this AC contains design criteria found acceptable to the FAA for type certification of powered-lift that meet the applicability in paragraph 5.2. These airworthiness criteria were developed from the airworthiness standards in parts 23, 27, 33, and 35 and include definitions and performance-based safety objectives specific for powered-lift and the installed electric engines and propellers.

4.2 In the event that the airworthiness criteria prescribed in appendix A of this AC are inadequate or otherwise inappropriate as a certification basis of a specific powered-lift due to its unique design or design features, other criteria may be developed using the process in paragraph 7.2 of this AC.

4.3 For new projects, applicants may propose using airworthiness criteria from the certification basis of previously approved powered-lift designs. Such a proposal should be evaluated for currency based upon advancement of the state-of-the-art powered-lift design, service experience, and amendments to relevant regulations, such as parts 23, 27, 33, and 35. This applies regardless of whether the applicant is proposing to reuse criteria from its prior project or from the project of another applicant.

4.4 Equivalent level of safety findings may be appropriate in lieu of changes to the criteria in appendix A of this AC. In such cases, a showing of equivalent safety should be proposed by the applicant and approved using the process as discussed in FAA Orders 8110.4 and 8110.112. Such equivalent safety findings become part of the type certification basis and are listed on the type certificate data sheet (TCDS).

4.5 The performance-based airworthiness criteria in appendix A capture the safety intent of each requirement. For each criteria, the specific means of compliance, proposed by the applicant and accepted by the FAA, will be a detailed design standard that, if met, accomplishes the safety intent of the criteria. The FAA will accept means of compliance found by the agency to be appropriate and applicable to the specific powered-lift design.

4.6 The airworthiness criteria in appendix A incorporate an "essential performance" approval, as well as an optional "increased performance" approval with greater aircraft performance capability requirements. Applicants must meet either the essential or increased performance requirements. Alternatively, applicants may propose designs that are approved for both essential and increased performance with appropriate and different operating limitations. The FAA expects that, for powered-lift intended for use in passenger-carrying operations for compensation or hire, applicants will seek approval for increased performance. Policy statement PS-AIR-21.17-01 identifies certification levels for powered-lift and establishes a graduated scale of compliance standards for the certification based on aircraft size and intended operation and should be used by applicants in the development of their proposed means of compliance.

5 APPLICABILITY.

5.1 The procedures in this AC apply to all powered-lift type certificated as special class under § 21.17(b).

5.2 The airworthiness criteria in appendix A of this AC apply to powered-lift with a maximum gross weight of 12,500 pounds or less, a passenger seating configuration of six or less, and a battery-powered electric engine(s) for propulsion.

6 TYPE CERTIFICATION PROCEDURES.

6.1 Application for Type Certification.

6.1.1 Application for type certification must be made in accordance with the requirements of § 21.15 as described in Order 8110.4.

6.1.2 An application for type certification of a powered-lift that meets the applicability of this AC is effective for 3 years as specified in § 21.17(c), unless an applicant shows at the time of application that the product requires a longer period of time for design, development, and testing, and the Administrator approves a longer period.

6.1.3 AIR-600 is responsible for national technical policy standardization concerning the development and use of powered-lift airworthiness criteria, including the type certification of powered-lift as special class of aircraft under § 21.17 (b). AIR-600 may participate at its discretion in powered-lift type certification projects. This will ensure that the airworthiness criteria developed for powered-lift are properly and consistently interpreted and applied.

6.2 Type Certification Basis.

The type certification basis reflected on the TCDS will be stated as 14 CFR 21.17(b), noting that the criteria in AC 21.17-4 appendix A (including the revision or publication date) was applied. If the engine and propeller are approved as part of the aircraft type design using the airworthiness criteria of appendix A subparts I and J, these criteria will also be noted on the TCDS. Otherwise, the engine and propeller model and type certificate numbers will be listed on the TCDS. Additionally, any equivalent level of safety findings and operating limitations (such as visual flight rules only) will be included in accordance with § 21.41.

6.3 Type Certification Procedures.

6.3.1 The general and procedural regulations of part 21, subparts A and B, are applicable to the type certification of powered-lift as special class aircraft.

6.3.2 Powered-lift type certificate holders are required to report failures, malfunctions, and defects under § 21.3. These reporting requirements also apply to the engine and propeller when they are approved as a part of the powered-lift type certificate.

6.4 Flight Testing.

6.4.1 Function and reliability (F&R) testing is required for most aircraft under § 21.35(b). An applicant must conduct flight tests for the FAA to determine that the aircraft, its components, and its equipment are reliable and function properly. F&R testing provides reasonable assurance in the propulsion and aircraft systems during operations. F&R testing is typically conducted on a dedicated aircraft with a complement of approved engines over a series of flights representing the operational spectrum of the proposed design.

6.4.2 Many powered-lift incorporate highly complex, integrated designs with distributed propulsion systems and flight control effectors. These aircraft no longer fit within the definitions and underlying assumptions used in establishing F&R testing requirements under § 21.35. Because powered-lift lack a pedigree of operational experience and demonstrated reliability, the FAA finds a need for more thorough flight testing. As such, the FAA expects to use at least 300 hours of operation, similar to the requirement in § 21.35(f)(1), as the baseline for powered-lift. However, the amount of dedicated F&R testing may be adjusted through other means, such as representative rig and bench tests with agreement from the FAA.

6.5 Instructions for Continued Airworthiness.

Instructions for continued airworthiness (ICA) are required for powered-lift in accordance with § 21.50.

6.6 Provisional Type Certificates.

The procedural requirements for the issuance of provisional type certificates in part 21, subpart C, are applicable to powered-lift.

6.7 Changes to Powered-Lift Type Certificates.

The procedural requirements of part 21, subparts D and E, are applicable for approving changes to type certificates issued for powered-lift designs, including the issuance of supplemental type certificates.

6.8 Production Approvals.

The procedural requirements in part 21, subparts F, G, K, and O for production approvals, including parts manufacturer approvals and technical standard order authorizations, are applicable to powered-lift and articles installed on powered-lift.

6.9 Airworthiness Certification.

The procedural requirements for the issuance of an airworthiness certificate in part 21, subparts H and I, apply to powered-lift. To receive a standard airworthiness certificate under § 21.183(a) or (b), the powered-lift must have a type certificate. Powered-lift will be issued standard airworthiness certificates in the same manner as any other aircraft receiving the same certificate. Since powered-lift are type certificated as special class of aircraft, the category in FAA Form 8100-2, block 4, will be identified as “Powered-lift—Special Class.” Powered-lift will also be issued special airworthiness certificates identified in § 21.175(b), using FAA Form 8130-7, in the same manner as any other aircraft receiving the same certificate.

6.10 Imported Products.

The import product type certification requirements of § 21.29 and import product airworthiness certification requirements of § 21.183(c) are applicable to powered-lift. The FAA type certification basis for import powered-lift will also be shown on the TCDS as 14 CFR 21.17(b).

6.11 Use of Designees.

Applicants may use the services of FAA designees provided the designee's authorization specifically includes special class aircraft – powered-lift. For example, designated engineering representatives (DERs), including DER flight tests pilots, with a special class aircraft – powered-lift authorization may be used to approve data or make findings of compliance for powered-lift. To approve data or make findings of compliance for the engines or propellers installed on powered-lift, they must also be specifically identified in the DER's authorization. Applicants may locate designees authorized under part 183 via the FAA's website at https://designee.faa.gov.

6.12 Airworthiness Directives.

Powered-lift are products as defined in § 39.3. Accordingly, airworthiness directives may be issued to address an unsafe condition in a powered-lift in accordance with part 39.

6.13 Major Repairs and Alterations.

Field approvals under the provisions of parts 43 and 145 may also be used to approve an altered or repaired individual powered-lift for return to service.

6.14 Identification and Registration Marking.

The identification and registration marking requirements of part 45 are applicable to powered-lift. AC 45-2, *Identification and Registration Marking*, provides guidance and information concerning the identification and marking requirements of part 45.

7 ACCEPTABLE CRITERIA.

7.1 Appendix A.

Applicants may use the airworthiness criteria in appendix A as the certification basis for a powered-lift that meets the applicability in paragraph 5.2. For designs that use only the criteria in appendix A for the certification basis with no additions or changes, the FAA does not need to announce the criteria in the *Federal Register* for notice and comment.

7.2 Other Airworthiness Criteria.

In the event the Administrator finds that compliance with airworthiness criteria in appendix A is inadequate or otherwise inappropriate as a certification basis of a powered-lift due to its unique design or design features, the Administrator may require an applicant to comply with alternate or additional criteria. Additionally, applicants may propose other criteria with their certification plan per the process in FAA Order 8110.4, *Type Certification*. If found to be acceptable by the Administrator, the FAA will propose and request public comment on any alternate and additional criteria in the *Federal Register*. After taking into account any comments received, the FAA will publish the final airworthiness criteria in the *Federal Register*. This final *Federal Register* notice will include disposition of the public comments. FAA approval of an applicant's proposed airworthiness criteria is required before the airworthiness criteria may be included in the certification basis of a powered-lift.

7.3 Special conditions under § 21.16 are not used as part of the certification basis for special classes of aircraft. An applicant for a powered-lift may propose to use alternate or new criteria instead of, or in addition to, the criteria in appendix A due to a unique, novel, or unusual design feature. However, it would be inappropriate to use special conditions. Instead, the FAA will use the process in paragraph 7.2 to include the alternate or new criteria in the special class certification basis.

7.4 Engine and Propeller Type Certification Options.

Powered-lift applicants have two options for the certification of engines and propellers.

7.4.1 The applicant may install type certificated engines or propellers under parts 33 or 35, respectively, as part of its powered-lift design.

7.4.2 The applicant may seek approval of the engines or propellers under the aircraft type certificate using the airworthiness criteria of appendix A, subparts I and J. In this case, ICA for the aircraft, engines, and propellers may be shown with the aircraft in a single aircraft ICA or the applicant may provide individual ICA for the aircraft, engines, and propellers in accordance with Order 8110.54.

7.5 Noise Regulations.

The FAA is mandated to establish noise standards and regulations that ensure public safety regarding aircraft noise. The FAA will examine each powered-lift application and determine whether the existing part 36 requirements are appropriate as a noise certification basis, as it does for all noise certification applicants. Part 36 does contain noise standards for tiltrotors, a class of aircraft within the powered-lift category. If the FAA determines that the part 36 noise standards are not sufficient for a particular powered-lift design, the FAA will prescribe a rule of particular applicability and publish the specific noise requirements for that powered-lift in the *Federal Register*.

8 WHERE TO FIND THIS AC.

You can find this AC on the FAA's website at https://www.faa.gov/regulations_policies/advisory_circulars and the DRS website at https://drs.faa.gov/.

9 SUGGESTIONS FOR IMPROVING THIS AC.

If you have suggestions for improving this AC, you may use the FAA Form 1320-73, *Advisory Circular Feedback Form*, at the end of this AC.

END

Appendix A. Airworthiness Criteria for Powered-Lift

AIRCRAFT LEVEL REQUIREMENTS

PL.1457 Cockpit voice recorders.

(a) Each cockpit voice recorder required by the operating rules of title 14, chapter I must be approved and must be installed so that it will record the following:

(1) Voice communications transmitted from or received in the aircraft by radio.

(2) Voice communications of flightcrew members on the flightdeck.

(3) Voice communications of flightcrew members on the flightdeck, using the aircraft's interphone system.

(4) Voice or audio signals identifying navigation or approach aids introduced into a headset or speaker.

(5) Voice communications of flightcrew members using the passenger loudspeaker system, if there is such a system and if the fourth channel is available in accordance with the requirements of paragraph (c)(4)(ii) of this section.

(6) If datalink communication equipment is installed, all datalink communications, using an approved data message set. Datalink messages must be recorded as the output signal from the communications unit that translates the signal into usable data.

(b) The recording requirements of paragraph (a)(2) of this section must be met by installing a cockpit-mounted area microphone, located in the best position for recording voice communications originating at the first and second pilot stations and voice communications of other crewmembers on the flightdeck when directed to those stations. The microphone must be so located and, if necessary, the preamplifiers and filters of the recorder must be so adjusted or supplemented, so that the intelligibility of the recorded communications is as high as practicable when recorded under flight cockpit noise conditions and played back. Repeated aural or visual playback of the record may be used in evaluating intelligibility.

(c) Each cockpit voice recorder must be installed so that the part of the communication or audio signals specified in paragraph (a) of this section obtained from each of the following sources is recorded on a separate channel:

(1) For the first channel, from each boom, mask, or handheld microphone, headset, or speaker used at the first pilot station.

(2) For the second channel from each boom, mask, or handheld microphone, headset, or speaker used at the second pilot station.

(3) For the third channel—from the cockpit-mounted area microphone.

(4) For the fourth channel from:

(i) Each boom, mask, or handheld microphone, headset, or speaker used at the station for the third and fourth crewmembers.

(ii) If the stations specified in paragraph (c)(4)(i) of this section are not required or if the signal at such a station is picked up by another channel, each microphone on the flightdeck that is used with the passenger loudspeaker system, if its signals are not picked up by another channel.

(5) And that as far as is practicable all sounds received by the microphone listed in paragraphs (c)(1), (2), and (4) of this section must be recorded without interruption irrespective of the position of the interphone-transmitter key switch. The design shall ensure that sidetone for the flightcrew is produced only when the interphone, public address system, or radio transmitters are in use.

(d) Each cockpit voice recorder must be installed so that:

(1)

(i) It receives its electrical power from the bus that provides the maximum reliability for operation of the cockpit voice recorder without jeopardizing service to essential or emergency loads.

(ii) It remains powered for as long as possible without jeopardizing emergency operation of the aircraft.

(2) There is an automatic means to simultaneously stop the recorder and prevent each erasure feature from functioning, within 10 minutes after crash impact.

(3) There is an aural or visual means for preflight checking of the recorder for proper operation.

(4) Any single electrical failure external to the recorder does not disable both the cockpit voice recorder and the flight data recorder.

(5) It has an independent power source—

(i) That provides 10 ±1 minutes of electrical power to operate both the cockpit voice recorder and cockpit-mounted area microphone;

(ii) That is located as close as practicable to the cockpit voice recorder; and

(iii) To which the cockpit voice recorder and cockpit-mounted area microphone are switched automatically in the event that all other power to the cockpit voice recorder is interrupted either by normal shutdown or by any other loss of power to the electrical power bus.

(6) It is in a separate container from the flight data recorder when both are required. If used to comply with only the cockpit voice recorder requirements, a combination unit may be installed.

(e) The recorder container must be located and mounted to minimize the probability of rupture of the container as a result of crash impact and consequent heat damage to the recorder from fire.

(1) Except as provided in paragraph (e)(2) of this section, the recorder container must be located as far aft as practicable, but need not be outside of the pressurized compartment, and may not be located where aft-mounted engines may crush the container during impact.

(2) If two separate combination digital flight data recorder and cockpit voice recorder units are installed instead of one cockpit voice recorder and one digital flight data recorder, the combination unit that is installed to comply with the cockpit voice recorder requirements may be located near the cockpit.

(f) If the cockpit voice recorder has a bulk erasure device, the installation must be designed to minimize the probability of inadvertent operation and actuation of the device during crash impact.

(g) Each recorder container must—

(1) Be either bright orange or bright yellow;

(2) Have reflective tape affixed to its external surface to facilitate its location under water; and

(3) Have an underwater locating device, when required by the operating rules of this chapter, on or adjacent to the container, which is secured in such manner that they are not likely to be separated during crash impact.

PL.1459 Flight data recorders.

(a) Each flight recorder required by the operating rules of title 14, chapter I must be installed so that—

(1) It is supplied with airspeed, altitude, and directional data obtained from sources that meet the aircraft level system requirements and the functionality specified in PL.2500;

(2) The vertical acceleration sensor is rigidly attached, and located longitudinally either within the approved center of gravity limits of the aircraft, or at a distance forward or aft of these limits that does not exceed 25 percent of the aircraft's mean aerodynamic chord;

(3)

(i) It receives its electrical power from the bus that provides the maximum reliability for operation of the flight data recorder without jeopardizing service to essential or emergency loads;

(ii) It remains powered for as long as possible without jeopardizing emergency operation of the aircraft;

(4) There is an aural or visual means for preflight checking of the recorder for proper recording of data in the storage medium;

(5) Except for recorders powered solely by the engine-driven electrical generator system, there is an automatic means to simultaneously stop a recorder that has a data erasure feature and prevent each erasure feature from functioning, within 10 minutes after crash impact;

(6) Any single electrical failure external to the recorder does not disable both the cockpit voice recorder and the flight data recorder; and

(7) It is in a separate container from the cockpit voice recorder when both are required. If used to comply with only the flight data recorder requirements, a combination unit may be installed. If a combination unit is installed as a cockpit voice recorder to comply with PL.1457(e)(2), a combination unit must be used to comply with this flight data recorder requirement.

(b) Each non-ejectable record container must be located and mounted so as to minimize the probability of container rupture resulting from crash impact and subsequent damage to the record from fire. In meeting this requirement, the record container must be located as far aft as practicable, but need not be aft of the pressurized compartment, and may not be where aft-mounted engines may crush the container upon impact.

(c) A correlation must be established between the flight recorder readings of airspeed, altitude, and heading and the corresponding readings (taking into account correction factors) of the first pilot's instruments. The correlation must cover the airspeed range over which the aircraft is to be operated, the range of altitude to which the aircraft is limited, and 360 degrees of heading. Correlation may be established on the ground as appropriate.

(d) Each recorder container must—

(1) Be either bright orange or bright yellow;

(2) Have reflective tape affixed to its external surface to facilitate its location under water; and

(3) Have an underwater locating device, when required by the operating rules of this chapter, on or adjacent to the container, which is secured in such a manner that they are not likely to be separated during crash impact.

(e) Any novel or unique design or operational characteristics of the aircraft shall be evaluated to determine if any dedicated parameters must be recorded on flight recorders in addition to or in place of existing requirements.

PL.1529 Instructions for continued airworthiness.

The applicant must prepare Instructions for Continued Airworthiness (ICA), in accordance with subparts K, L, and M, that are acceptable to the Administrator. ICA for the aircraft, engines, and propellers may be shown in a single aircraft ICA manual if the engine and propeller approvals are sought through the aircraft certification program. Alternatively, the applicant may provide individual ICA for the aircraft, engines, and propellers. The instructions may be incomplete at the time of type certification if a program exists to ensure their completion prior to delivery of the first aircraft, or issuance of a standard certificate of airworthiness, whichever occurs later.

SUBPART A—GENERAL

PL.2000 Applicability and definitions.

(a) These airworthiness criteria prescribe airworthiness standards for the issuance of a type certificate, and changes to that type certificate, for powered-lift with maximum weights of 12,500 pounds or less and a maximum passenger seating configuration of six or less. The aircraft must be certificated in accordance with either the “essential performance” or “increased performance” requirements of these airworthiness criteria. The aircraft may also be type certificated as both “essential performance” and “increased performance” with appropriate and different operating limitations for each approval.

(b) For purposes of these airworthiness criteria, the following definitions apply:

(1) *Continued safe flight and landing* –

(i) for powered-lift approved for “essential performance” means the aircraft is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.

(ii) for powered-lift approved for “increased performance” means the aircraft is capable of climbing to a safe altitude, on a flightpath clear of obstacles, and maintaining level flight to a planned destination or alternate landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.

(2) *Phases of flight* means ground operations, takeoff, climb, cruise, descent, approach, hover, and landing.

(3) *Source of lift* means one of three sources of lift: thrust-borne, wing-borne, and semi-thrust-borne. Thrust-borne is defined as when the weight of the aircraft is principally supported by lift generated by engine-driven lift devices. Wing-borne is defined as when the weight of the aircraft is principally supported by aerodynamic lift from fixed airfoil surfaces. Semi-thrust-borne is the combination of thrust-borne and wing-borne, where both forms of lift are used to support the weight of the aircraft.

(4) *Controlled emergency landing* means the aircraft design retains the capability to allow the pilot to choose the direction and area of touchdown while reasonably protecting occupants from serious injury. Upon landing, some damage to the aircraft may be acceptable.

(5) *Critical change of thrust* means the most adverse effect on performance or handling qualities resulting from failures of the flight control or propulsive system, either singular or in combination, not shown to be extremely improbable.

(6) *Local events* are failures of aircraft systems and components, other than the engine and propeller control system, that may affect the installed environment of the engine and propeller control system.

PL.2010 Accepted means of compliance.

(a) An applicant must comply with these airworthiness criteria using a means of compliance, which may include consensus standards, accepted by the Administrator.

(b) An applicant requesting acceptance of a means of compliance must provide the means of compliance to the FAA in a form and manner acceptable to the Administrator.

SUBPART B—FLIGHT

Performance

PL.2100 Weight and center of gravity.

(a) The applicant must determine limits for weights and centers of gravity that provide for the safe operation of the aircraft.

(b) The applicant must comply with each requirement of this subpart at critical combinations of weight and center of gravity within the aircraft's range of loading conditions using tolerances acceptable to the Administrator.

(c) The condition of the aircraft at the time of determining its empty weight and center of gravity must be well defined and easily repeatable.

PL.2105 Performance data.

(a) Unless otherwise prescribed, the aircraft must meet the performance requirements of this subpart in still air and standard atmospheric conditions.

(b) Unless otherwise prescribed, the applicant must develop the performance data required by this subpart for the following conditions:

(1) Altitudes from sea level to the maximum altitude for which certification is being sought; and

(2) Temperatures above and below standard day temperature that are within the range of operating limitations, if those temperatures could have a negative effect on performance.

(c) The procedures used for determining takeoff and landing performance must be executable consistently by pilots of average skill in atmospheric conditions expected to be encountered in service.

(d) Performance data determined in accordance with paragraph (b) of this section must account for losses due to atmospheric conditions, cooling needs, installation losses, downwash considerations, and other demands on power sources.

(e) The hovering ceiling, in and out of ground effect, must be determined over the ranges of weight, altitude, and temperature, if applicable.

(f) Continued safe flight and landing must be possible from any point within the approved flight envelope following a critical change of thrust.

(g) The aircraft must be capable of a controlled emergency landing, following a condition when the aircraft can no longer provide the commanded power or thrust required for continued safe flight and landing, by gliding or autorotation, or an equivalent means to mitigate the risk of loss of power or thrust.

PL.2110 Minimum safe speed.

The applicant must determine the aircraft minimum safe speed for each flight condition encountered in normal operations, including applicable sources of lift and phases of flight, to maintain controlled safe flight. The minimum safe speed determination must account for the most adverse conditions for each flight configuration.

PL.2115 Takeoff performance.

(a) The applicant must determine takeoff performance accounting for:

(1) All sources of lift for each takeoff flight path for which certification is sought,

(2) Minimum safe speed safety margins,

(3) Minimum control speeds, and

(4) Climb requirements.

(b) For aircraft approved for essential performance, the applicant must determine the takeoff performance to 50 feet above the takeoff surface such that a rejected takeoff resulting in safe stop or landing can be made at any point along the takeoff flight path following a critical change of thrust.

(c) For aircraft approved for increased performance, the applicant must determine the takeoff performance so that—

(1) Following a critical change of thrust prior to reaching the takeoff decision point, a rejected takeoff resulting in a safe stop or landing can be made. The takeoff decision point may be a speed, an altitude, or both; and

(2) Following a critical change of thrust after passing the takeoff decision point, the aircraft can—

(i) Continue the takeoff and climb to 50 feet above the takeoff surface; and

(ii) Subsequently achieve the configuration and airspeed used in compliance with PL.2120.

PL.2120 Climb requirements.

(a) The applicant must demonstrate minimum climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) For aircraft approved for essential and increased performance, the applicant must determine the following all engines operating (AEO) climb performance requirements:

(1) A steady climb gradient at sea level of at least 8.3 percent in the initial takeoff configuration(s) and a climb speed selected by the applicant or V_y, and

(2) For a balked landing, a climb gradient of 3 percent without creating undue pilot workload with the landing gear extended and flaps in the landing configuration(s).

(c) For aircraft approved for essential performance, the climb performance after a critical change of thrust must be determined–

(1) Using applicable sources of lift along the takeoff flight path for which certification is being sought at the speeds and configurations selected by the applicant; and

(2) For the transition from the takeoff to the enroute configuration. The total altitude loss must be determined for the weight, altitude, and ambient temperature where level flight cannot be maintained.

(d) For aircraft approved for increased performance, the climb performance after a critical change of thrust must be such that–

(1) In thrust-borne and semi-thrust-borne flight:

(i) The steady rate of climb without ground effect, 200 feet above the takeoff surface, is at least 100 feet per minute,

(ii) The steady rate of climb without ground effect, 1000 feet above the takeoff surface, is at least 150 feet per minute,

(iii) The steady rate of climb (or descent) enroute is determined in feet per minute, at each weight, altitude, and temperature at which the aircraft is expected to operate for which certification is requested.

(2) In wing-borne flight, the steady gradient of climb:

(i) During takeoff at the takeoff surface, is at least 0.5 percent with the aircraft in its takeoff configuration(s),

(ii) During takeoff at 400 feet above the takeoff surface, is at least 2.6 percent with the aircraft in its second segment configuration,

(iii) Enroute at 1,500 feet above the takeoff or landing surface, as appropriate, is at least 1.7 percent with the aircraft in a cruise configuration, and

(iv) During a discontinued approach at 400 feet above the landing surface, is not less than 2.7 percent in an approach configuration.

(e) The applicant must determine the performance accordingly for the appropriate sources of lift for gliding, autorotation, or the equivalent means established under PL.2105(g).

PL.2125 Climb information.

(a) The applicant must determine climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) The applicant must determine climb performance accounting for any critical change of thrust.

(c) The applicant must determine the performance accordingly for the appropriate sources of lift for gliding, autorotation, or equivalent means applicable to the condition defined in PL.2105(g).

PL.2130 Landing.

The applicant must determine the following, for standard temperatures at critical combinations of weight and altitude within the operational limits:

(a) The approach and landing speeds and procedures, which allow a pilot of average skill to land within the published landing distance consistently and without causing damage or injury, and which allow for a safe transition to the balked landing conditions of these airworthiness criteria accounting for:

(1) All sources of lift for each approach and landing flight path for which certification is sought,

(2) Any minimum or maximum speed safety margins, and

(3) Minimum control speeds.

(b) For aircraft approved for essential performance, the applicant must determine the landing performance from a height of 50 feet above the landing surface. Additionally, the aircraft must be capable of performing a safe landing at any point along the approach flight path following a critical change of thrust.

(c) For aircraft approved for increased performance, the applicant must determine the landing performance from a height of 50 feet above the landing surface so that, following a critical change of thrust that occurs prior to the landing decision point, the aircraft can-

(1) Land and stop safely on the landing surface; or

(2) Transition to the balked landing condition and performance established in PL.2120.

Flight Characteristics

PL.2135 Controllability.

(a) The aircraft must be controllable and maneuverable, without requiring exceptional piloting skill, alertness, or strength, within the approved flight envelope—

(1) At all loading conditions for which certification is requested;

(2) During all phases of flight while using applicable sources of lift;

(3) With likely flight control or propulsion system failure;

(4) During configuration changes;

(5) In all degraded flight control system operating modes not shown to be extremely improbable;

(6) In thrust-borne operation, and must be controllable in wind velocities from zero to at least 17 knots from any azimuth angle; and

(7) The aircraft must be able to safely complete a landing using the steepest approach gradient procedures.

(b) The applicant must determine critical control parameters, such as limited control power margins, and if applicable, account for those parameters in appropriate operating limitations.

(c) It must be possible to make a smooth transition from one flight condition to another (changes in configuration and in source of lift and phase of flight) without exceeding the approved flight envelope.

PL.2140 Trim.

(a) The aircraft must maintain lateral and directional trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under all normal operations while using applicable sources of lift.

(b) The aircraft must maintain longitudinal trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under the following conditions:

(1) Climb.

(2) Level flight.

(3) Descent.

(4) Approach.

(c) Residual control forces must not fatigue or distract the pilot during normal operations of the aircraft and likely abnormal or emergency operations, including a critical change of thrust.

PL.2145 Stability.

(a) The aircraft must exhibit static stability characteristics inclusive of likely failures.

(b) The aircraft must exhibit suitable short period dynamic stability inclusive of likely failures.

(c) For wing borne and semi-thrust-borne operations:

(1) No aircraft may exhibit any divergent longitudinal dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants, and

(2) The aircraft must exhibit lateral-directional dynamic stability inclusive of likely failures.

(d) For thrust borne operations, no aircraft may exhibit any divergent dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants.

PL.2150 Minimum safe speed characteristics and warning.

(a) When part of the lift is generated from a fixed wing, the aircraft must have controllable stall characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive stall warning that provides sufficient margin to prevent inadvertent stalling and not have a tendency to inadvertently depart controlled safe flight.

(b) For other sources of lift, the aircraft must have controllable characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive warning that provides sufficient margin to prevent inadvertent departures from controlled safe flight.

(c) For all sources of lift, the aircraft must not have the tendency to inadvertently depart controlled safe flight after a sudden change of thrust.

PL.2155 Ground and water handling characteristics.

For aircraft intended for operation on land or water, the aircraft must have controllable longitudinal and directional handling characteristics during taxi, takeoff, and landing operations.

PL.2160 Vibration, buffeting, and high-speed characteristics.

(a) Each part of the aircraft must be free from excessive vibration and buffeting under each appropriate speed and power condition. Vibration and buffeting, for operations up to V_D/M_D, must not interfere with the control of the aircraft or cause excessive fatigue to the flightcrew. Stall warning buffet within these limits is allowable.

(b) For inadvertent excursions beyond the maximum approved speed, the aircraft must be able to safely recover back to its approved flight envelope without requiring exceptional piloting skill, strength, or alertness. This recovery may not result in structural damage or loss of control.

PL.2165 Performance and flight characteristics requirements for flight in atmospheric icing conditions.

(a) An applicant who requests certification for flight in atmospheric icing conditions must show the following in the icing conditions for which certification is requested:

(1) Compliance with each requirement of this subpart, except those applicable to spins and any that must be demonstrated at speeds in excess of—

(i) 250 knots calibrated airspeed (CAS);

(ii) VMO/MMO or VNE; or

(iii) A speed at which the applicant demonstrates the airframe will be free of ice accretion.

(b) The applicant must provide a means to detect icing conditions for which certification is not requested and show the aircraft's ability to avoid or exit those icing conditions.

(c) The applicant must develop an operating limitation to prohibit intentional flight, including takeoff and landing, into icing conditions for which the aircraft is not certified to operate.

SUBPART C—STRUCTURES

PL.2200 Structural design envelope.

The applicant must determine the structural design envelope, which describes the range and limits of aircraft design and operational parameters for which the applicant will show compliance with the requirements of this subpart. The applicant must account for all aircraft design and operational parameters that affect structural loads, strength, durability, and aeroelasticity, including:

(a) Structural design airspeeds, landing descent speeds, and any other airspeed limitation at which the applicant must show compliance to the requirements of this subpart. The structural design airspeeds must—

(1) Be sufficiently greater than the minimum safe speed of the aircraft to safeguard against loss of control in turbulent air; and

(2) Provide sufficient margin for the establishment of practical operational limiting airspeeds.

(b) Design maneuvering load factors not less than those, which service history shows, may occur within the structural design envelope.

(c) Inertial properties including weight, center of gravity, and mass moments of inertia, accounting for—

(1) Each critical weight from the aircraft empty weight to the maximum weight; and

(2) The weight and distribution of occupants, payload, and energy-storage systems.

(d) Characteristics of aircraft control systems, including range of motion and tolerances for control surfaces, high lift devices, or other moveable surfaces.

(e) Each critical altitude up to the maximum altitude.

(f) Engine-driven lifting-device rotational speed and ranges, and the maximum rearward and sideward flight speeds.

(g) Thrust-borne, wing-borne, and semi-thrust-borne flight configurations, with associated flight load envelopes.

PL.2205 Interaction of systems and structures.

For aircraft equipped with systems that modify structural performance, alleviate the impact of this subpart's requirements, or provide a means of compliance with this subpart, the applicant must account for the influence and failure of these systems when showing compliance with the requirements of this subpart.

Structural Loads

PL.2210 Structural design loads.

(a) The applicant must:

(1) Determine the applicable structural design loads resulting from likely externally or internally applied pressures, forces, or moments that may occur in flight, ground and water operations, ground and water handling, and while the aircraft is parked or moored.

(2) Determine the loads required by paragraph (a)(1) of this section at all critical combinations of parameters, on and within the boundaries of the structural design envelope.

(b) The magnitude and distribution of the applicable structural design loads required by this section must be based on physical principles.

PL.2215 Flight load conditions.

(a) The applicant must determine the structural design loads resulting from the following flight conditions:

(1) Atmospheric gusts where the magnitude and gradient of these gusts are based on measured gust statistics.

(2) Symmetric and asymmetric maneuvers.

(3) Asymmetric thrust resulting from the failure of a powerplant unit.

(b) There must be no vibration or buffeting severe enough to result in structural damage, at any speed up to dive speed, within the structural design envelope, in any configuration and power setting.

PL.2220 Ground and water load conditions.

The applicant must determine the structural design loads resulting from taxi, takeoff, landing, and handling conditions on the applicable surface in normal and adverse attitudes and configurations.

PL.2225 Component loading conditions.

The applicant must determine the structural design loads acting on:

(a) Each engine mount and its supporting structure such that both are designed to withstand loads resulting from—

(1) Powerplant operation combined with flight gust and maneuver loads; and

(2) For non-reciprocating powerplants, sudden powerplant stoppage.

(b) Each flight control and high-lift surface, their associated system and supporting structure resulting from—

(1) The inertia of each surface and mass balance attachment;

(2) Flight gusts and maneuvers;

(3) Pilot or automated system inputs;

(4) System induced conditions, including jamming and friction; and

(5) Taxi, takeoff, and landing operations on the applicable surface, including downwind taxi and gusts occurring on the applicable surface.

(c) A pressurized cabin resulting from the pressurization differential—

(1) From zero up to the maximum relief pressure combined with gust and maneuver loads;

(2) From zero up to the maximum relief pressure combined with ground and water loads if the aircraft may land with the cabin pressurized; and

(3) At the maximum relief pressure multiplied by 1.33, omitting all other loads.

(d) Engine-driven lifting-device assemblies, considering loads resulting from flight and ground conditions, as well limit input torque at any lifting-device rotational speed.

PL.2230 Limit and ultimate loads.

The applicant must determine—

(a) The limit loads, which are equal to the structural design loads unless otherwise specified elsewhere in these airworthiness criteria; and

(b) The ultimate loads, which are equal to the limit loads multiplied by a 1.5 factor of safety unless otherwise specified elsewhere in these airworthiness criteria.

Structural Performance

PL.2235 Structural strength.

The structure must support:

(a) Limit loads without—

(1) Interference with the safe operation of the aircraft; and

(2) Detrimental or permanent deformation.

(b) Ultimate loads.

PL.2240 Structural durability.

(a) The applicant must develop and implement inspections or other procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, or extended periods of operation with reduced safety margins. Each of the inspections or other procedures developed under this section must be included in the Airworthiness Limitations Section of the ICA, required by PL.1529.

(b) If safety-by-design (fail-safe) is used to comply with paragraph (a) of this section, safety-by-inspection (damage tolerance) must also be incorporated to reliably detect structural damage before the damage could result in structural failure.

(c) For pressurized aircraft:

(1) The aircraft must be capable of continued safe flight and landing following a sudden release of cabin pressure, including sudden releases caused by door and window failures.

(2) For aircraft with maximum operating altitude greater than 41,000 feet, the procedures developed for compliance with paragraph (a) of this section must be capable of detecting damage to the pressurized cabin structure before the damage could result in rapid decompression that would result in serious or fatal injuries.

(d) The aircraft must be designed to minimize hazards to the aircraft due to structural damage caused by high-energy fragments from an uncontained engine or rotating machinery failure.

PL.2241 Aeromechanical stability.

The aircraft must be free from dangerous oscillations and aeromechanical instabilities for all configurations and conditions of operation on the ground and in flight.

PL.2245 Aeroelasticity.

(a) The aircraft must be free from flutter, control reversal, and divergence—

(1) At all speeds within and sufficiently beyond the structural design envelope;

(2) For any configuration and condition of operation;

(3) Accounting for critical structural modes, and

(4) Accounting for any critical failures or malfunctions.

(b) The applicant must establish tolerances for all quantities that affect aeroelastic stability

(c) Each component and rotating aerodynamic surface of the aircraft must be free from any aeroelastic instability under each appropriate speed and power condition.

Design

PL.2250 Design and construction principles.

(a) The applicant must design each part, article, and assembly for the expected operating conditions of the aircraft.

(b) Design data must adequately define the part, article, or assembly configuration, its design features, and any materials and processes used.

(c) The applicant must determine the suitability of each design detail and part having an important bearing on safety in operations. The applicant must prevent single failures from resulting in a catastrophic effect upon the aircraft.

(d) The control system must be free from jamming, excessive friction, and excessive deflection when the aircraft is subjected to expected limit airloads.

(e) Doors, canopies, and exits must be protected against inadvertent opening in flight, unless shown to create no hazard when opened in flight.

PL.2255 Protection of structure.

(a) The applicant must protect each part of the aircraft, including small parts such as fasteners, against deterioration or loss of strength due to any cause likely to occur in the expected operational environment.

(b) Each part of the aircraft must have adequate provisions for ventilation and drainage.

(c) For each part that requires maintenance, preventive maintenance, or servicing, the applicant must incorporate a means into the aircraft design to allow such actions to be accomplished.

PL.2260 Materials and processes.

(a) The applicant must determine the suitability and durability of materials used for parts, articles, and assemblies, accounting for the effects of likely environmental conditions expected in service, the failure of which could prevent continued safe flight and landing.

(b) The methods and processes of fabrication and assembly used must produce consistently sound structures. If a fabrication process requires close control to reach this objective, the applicant must perform the process under an approved process specification.

(c) Except as provided in paragraphs (f) and (g) of this section, the applicant must select design values that ensure material strength with probabilities that account for the criticality of the structural element. Design values must account for the probability of structural failure due to material variability.

(d) If material strength properties are required, a determination of those properties must be based on sufficient tests of material meeting specifications to establish design values on a statistical basis.

(e) If thermal effects are significant on a critical component or structure under normal operating conditions, the applicant must determine those effects on allowable stresses used for design.

(f) Design values, greater than the minimums specified by this section, may be used, where only guaranteed minimum values are normally allowed, if a specimen of each individual item is tested before use to determine that the actual strength properties of that particular item will equal or exceed those used in the design.

(g) An applicant may use other material design values if approved by the Administrator.

PL.2265 Special factors of safety.

(a) The applicant must determine a special factor of safety for each critical design value for each part, article, or assembly for which that critical design value is uncertain, and for each part, article, or assembly that is—

(1) Likely to deteriorate in service before normal replacement; or

(2) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

(b) The applicant must determine a special factor of safety using quality controls and specifications that account for each—

(1) Type of application;

(2) Inspection method;

(3) Structural test requirement;

(4) Sampling percentage; and

(5) Process and material control.

(c) The applicant must multiply the highest pertinent special factor of safety in the design for each part of the structure by each limit and ultimate load, or ultimate load only, if there is no corresponding limit load, such as occurs with emergency condition loading.

Structural Occupant Protection

PL.2270 Emergency conditions.

(a) The aircraft, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress when—

(1) Properly using safety equipment and features provided for in the design;

(2) The occupant experiences ultimate static inertia loads likely to occur in an emergency landing; and

(3) Items of mass, including engines or auxiliary power units (APUs), within or aft of the cabin, that could injure an occupant, experience ultimate static inertia loads likely to occur in an emergency landing.

(b) The emergency landing conditions specified in paragraph (a)(1) and (a)(2) of this section, must—

(1) Include dynamic conditions that are likely to occur in an emergency landing; and

(2) Not generate loads experienced by the occupants, which exceed established human injury criteria for human tolerance due to restraint or contact with objects in the aircraft.

(c) The aircraft must provide protection for all occupants, accounting for likely flight, ground, and emergency landing conditions.

(d) Each occupant protection system must perform its intended function and not create a hazard that could cause a secondary injury to an occupant. The occupant protection system must not prevent occupant egress or interfere with the operation of the aircraft when not in use.

(e) Each baggage and cargo compartment must—

(1) Be designed for its maximum weight of contents and for the critical load distributions at the maximum load factors corresponding to the flight and ground load conditions determined under these airworthiness criteria;

(2) Have a means to prevent the contents of the compartment from becoming a hazard by impacting occupants or shifting; and

(3) Protect any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operations.

SUBPART D—DESIGN AND CONSTRUCTION

PL.2300 Flight control systems.

(a) The applicant must design flight control systems to:

(1) Operate easily, smoothly, and positively enough to allow proper performance of their functions;

(2) Protect against likely hazards; and

(3) Ensure that the flightcrew is made suitably aware whenever the means of primary flight control approaches the limits of control authority.

(b) The applicant must design trim systems or trim functions, if installed, to:

(1) Protect against inadvertent, incorrect, or abrupt trim operation; and

(2) Provide information that is required for safe operation.

(c) Features that protect the aircraft against loss of control, or exceeding critical limits, must be designed such that there are no adverse flight characteristics in aircraft response to flight-control inputs, unsteady atmospheric conditions, and other likely conditions, including simultaneous limiting events.

PL.2305 Landing gear systems.

(a) The landing gear must be designed to—

(1) Provide stable support and control to the aircraft during surface operation; and

(2) Account for likely system failures and likely operation environments (including anticipated limitation exceedances and emergency procedures).

(b) All aircraft must have a reliable means of stopping the aircraft with sufficient kinetic energy absorption to account for landing. Aircraft that are required to demonstrate aborted takeoff capability must account for this additional kinetic energy.

(c) For aircraft that have a system that actuates the landing gear, there is—

(1) A positive means to keep the landing gear in the landing position; and

(2) An alternative means available to bring the landing gear in the landing position when a non-deployed system position would be a hazard.

PL.2310 Flotation.

(a) If certification for intended operations on water is requested, the aircraft must—

(1) Provide buoyancy of 80% in excess of the buoyancy required to support the maximum weight of the aircraft in fresh water; and

(2) Have sufficient margin so that the aircraft will stay afloat at rest in calm water without capsizing in case of a likely float or hull flooding.

(b) If certification for emergency flotation is requested, the aircraft must:

(1) Be equipped with an approved emergency flotation system;

(2) Have flotation units of the emergency flotation system and their attachments to the aircraft capable of withstanding the applicable water loads; and

(3) Be shown to maintain its intended floating attitude in the sea conditions selected by the applicant.

(c) If certification with ditching provisions is requested, the aircraft must:

(1) Be equipped with an approved emergency flotation system that does not rely on manual activation;

(2) Withstand the applicable water loads; and

(3) Be shown to have a safe water entry and to maintain its intended floating attitude in the sea conditions selected by the applicant.

PL.2311 Bird Strike.

The aircraft must be capable of continued safe flight and landing after impact with a 2.2-lb (1.0 kg) bird.

Occupant System Design Protection

PL.2315 Means of egress and emergency exits.

With the cabin configured for takeoff or landing, the aircraft is designed to:

(a) Facilitate rapid and safe evacuation of the aircraft in conditions likely to occur following an emergency landing, including on water if an emergency flotation system is included.

(b) Have means of egress (openings, exits, or emergency exits), that can be readily located and opened from the inside and outside. The means of opening must be simple and obvious and marked inside and outside the aircraft. If an emergency flotation system is included, the means of egress must be above the water in the intended floating attitude.

(c) Have easy access to emergency exits when present.

PL.2320 Occupant physical environment.

(a) The applicant must design the aircraft to—

(1) Allow clear communication between the flightcrew and passengers;

(2) Protect the pilot and flight controls from propellers; and

(3) Protect the occupants from serious injury due to damage to windshields, windows, and canopies.

(b) The aircraft must provide each occupant with air at a breathable pressure, free of hazardous concentrations of gases, vapors, and smoke during normal operations and likely failures.

(c) If a pressurization system is installed in the aircraft, it must be designed to protect against—

(1) Decompression to an unsafe level; and

(2) Excessive differential pressure.

(d) If an oxygen system is installed in the aircraft, it must—

(1) Effectively provide oxygen to each user to prevent the effects of hypoxia; and

(2) Be free from hazards in itself, in its method of operation, and its effect upon other components.

Fire and High Energy Protection

PL.2325 Fire protection.

(a) The following materials must be self-extinguishing—

(1) Insulation on electrical wire and electrical cable; and

(2) Materials in the baggage and cargo compartments inaccessible in flight.

(b) The following materials must be flame resistant—

(1) Materials in each compartment accessible in flight; and

(2) Any equipment associated with any electrical cable installation and that would overheat in the event of circuit overload or fault.

(c) Thermal/acoustic materials in the fuselage, if installed, must not be a flame propagation hazard.

(d) Sources of heat within each baggage and cargo compartment that are capable of igniting adjacent objects must be shielded and insulated to prevent such ignition.

(e) Each baggage and cargo compartment must—

(1) Be located where a fire would be visible to the pilots and be accessible for the manual extinguishing of a fire,

(2) Be equipped with a smoke or fire detection system that warns the pilot, or

(3) Be constructed of, or lined with, fire resistant materials.

(f) There must be a means to extinguish any fire in the cabin such that the pilot, while seated, can easily access the fire extinguishing means.

(g) Each area where flammable fluids or vapors might escape by leakage of a fluid system must -

(1) Be defined; and

(2) Have a means to minimize the probability of fluid and vapor ignition, and the resultant hazard, if ignition occurs.

PL.2330 Fire protection in fire zones and adjacent areas.

(a) Flight controls, engine mounts, and other flight structures within or adjacent to fire zones must be capable of withstanding the effects of a fire.

(b) Engines in a fire zone must remain attached to the aircraft in the event of a fire.

(c) In fire zones, terminals, equipment, and electrical cables used during emergency procedures must perform their intended function in the event of a fire.

PL.2335 Lightning and static electricity protection.

(a) The aircraft must be protected against catastrophic effects from lightning.

(b) The aircraft must be protected against hazardous effects caused by an accumulation of electrostatic charge.

SUBPART E—POWERPLANT

PL.2400 Powerplant installation.

(a) For the purpose of this subpart, the aircraft powerplant installation must include each component necessary for propulsion, which affects propulsion safety.

(b) Each aircraft engine and propeller must have a type certificate or be approved under the aircraft type certificate using criteria found in subparts I and J.

(c) The applicant must construct and arrange each powerplant installation to account for—

(1) Likely operating conditions, including foreign-object threats;

(2) Sufficient clearance of moving parts to other aircraft parts and their surroundings;

(3) Likely hazards in operation including hazards to ground personnel; and

(4) Vibration and fatigue.

(d) Hazardous accumulations of fluids, vapors, or gases must be isolated from the aircraft and personnel compartments and be safely contained or discharged.

(e) Powerplant components must comply with their component limitations and installation instructions or be shown not to create a hazard.

PL.2405 Power or thrust control systems.

(a) Any power or thrust control system or powerplant control system must be designed so no unsafe condition results during normal operation of the system.

(b) Any single failure or likely combination of failures or malfunctions of a power or thrust control system or powerplant control system must not prevent continued safe flight and landing of the aircraft.

(c) Inadvertent flightcrew operation of a power or thrust control system or powerplant control system must be prevented, or if not prevented, must not prevent continued safe flight and landing of the aircraft.

PL.2410 Powerplant installation hazard assessment.

The applicant must assess each powerplant separately and in relation to other aircraft systems and installations to show that any hazard resulting from the likely failure of any powerplant system, component, or accessory will not—

(a) Prevent continued safe flight and landing or, if continued safe flight and landing cannot be ensured, the hazard has been minimized;

(b) Cause serious injury that may be avoided; and

(c) Require immediate action by any crewmember for continued operation of any remaining powerplant system.

PL.2415 Powerplant ice protection.

(a) The aircraft design, including the induction and inlet system, must prevent foreseeable accumulation of ice or snow that adversely affects powerplant operation.

(b) The powerplant installation design must prevent any accumulation of ice or snow that adversely affects powerplant operation, in those icing conditions for which certification is requested.

PL.2425 Powerplant operational characteristics.

(a) Each installed powerplant must operate without any hazardous characteristics during normal and emergency operation within the range of operating limitations for the aircraft and the engine.

(b) The design must provide for the shutdown and restart of the powerplant in flight within an established operational envelope.

PL.2430 Energy systems.

(a) Each energy system must—

(1) Be designed and arranged to provide independence between multiple energy-storage and supply systems, so that failure of any one component in one system will not result in loss of energy storage or supply of another system;

(2) Be designed to prevent catastrophic events due to lightning strikes, taking into account direct and indirect effects on the aircraft;

(3) Provide the energy necessary to ensure each powerplant functions properly in all likely operating conditions;

(4) Provide the flightcrew with a means to determine the total useable energy available and provide uninterrupted supply of that energy when the system is correctly operated, accounting for likely energy fluctuations;

(5) Provide a means to safely remove or isolate the energy stored in the system from the aircraft; and

(6) Be designed to retain energy under all likely operating conditions and to minimize hazards to occupants and first responders following an emergency landing or otherwise survivable impact (crash landing).

(b) Each energy-storage system must—

(1) Withstand the loads under likely operating conditions without failure; and

(2) Be isolated from personnel compartments and protected from likely hazards.

(c) Each energy-storage recharging system must be designed to—

(1) Prevent improper recharging; and

(2) Prevent the occurrence of hazard to the aircraft or to persons during recharging.

PL.2440 Powerplant fire protection.

There must be means to isolate and mitigate hazards to the aircraft in the event of a powerplant system fire or overheat in operation.

SUBPART F—EQUIPMENT

PL.2500 Aircraft level systems requirements.

This section applies generally to installed equipment and systems unless a section of these airworthiness criteria imposes requirements for a specific piece of equipment, system, or systems.

(a) The equipment and systems required for an aircraft to operate safely in the kinds of operations for which certification is requested must be designed and installed to—

(1) Meet the level of safety applicable to the certification and performance level of the aircraft; and

(2) Perform their intended function throughout the operating and environmental limits for which the aircraft is certificated.

(b) The systems and equipment not covered by paragraph (a) of this section, considered separately and in relation to other systems, must be designed and installed so their operation does not have an adverse effect on the aircraft or its occupants.

PL.2505 Function and installation.

When installed, each item of equipment must function as intended.

PL.2510 Equipment, systems, and installations.

For any aircraft system or equipment whose failure or abnormal operation has not been specifically addressed by another requirement in these airworthiness criteria, the applicant must design and install each system and equipment, such that there is a logical and acceptable inverse relationship between the average probability and the severity of failure conditions to the extent that:

(a) Each catastrophic failure condition is extremely improbable;

(b) Each hazardous failure condition is extremely remote; and

(c) Each major failure condition is remote.

PL.2515 Electrical- and electronic-system lightning protection.

(a) Each electrical or electronic system that performs a function, the failure of which would prevent the continued safe flight and landing of the aircraft, must be designed and installed such that—

(1) The function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to lightning; and

(2) The system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) For an aircraft approved for operation under instrument flight rules (IFR), each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning.

PL.2520 High-intensity Radiated Fields (HIRF) protection.

(a) Each electrical or electronic system that performs a function, the failure of which would prevent the continued safe flight and landing of the aircraft, must be designed and installed such that—

(1) The function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to the HIRF environment; and

(2) The system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment, unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) For aircraft approved for IFR operations, each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment.

PL.2525 System power generation, storage, and distribution.

The power generation, storage, and distribution for any system must be designed and installed to—

(a) Supply the power required for operation of connected loads during all intended operating conditions;

(b) Ensure no single failure or malfunction of any one power supply, distribution system, or other utilization system will prevent the system from supplying the essential loads required for continued safe flight and landing; and

(c) Have enough capacity, if the primary source fails, to supply essential loads, including non-continuous essential loads for the time needed to complete the function required for continued safe flight and landing.

PL.2530 External and cockpit lighting.

(a) The applicant must design and install all lights to minimize any adverse effects on the performance of flightcrew duties.

(b) Any position and anti-collision lights, if required by 14 CFR part 91, must have the intensities, flash rate, colors, fields of coverage, and other characteristics to provide sufficient time for another aircraft to avoid a collision.

(c) Any position lights, if required by 14 CFR part 91, must include red lighting on the left side of the aircraft, green lighting on the right side of the aircraft, spaced laterally as far apart as practicable, and white lighting facing aft, located on an aft portion of the aircraft or on the wing tips.

(d) Any taxi and landing lights must be designed and installed so they provide sufficient light for night operations.

(e) For aircraft intended for operations on water, riding lights must provide a white light visible in clear atmospheric conditions.

PL.2535 Safety equipment.

Safety and survival equipment, required by the operating rules of title 14, chapter I, must be reliable, readily accessible, easily identifiable, and clearly marked to identify its method of operation.

PL.2540 Flight in icing conditions.

An applicant who requests certification for flight in icing conditions must show the following in the icing conditions for which certification is requested:

(a) The ice protection system provides for safe operation; and

(b) The aircraft design must provide protection from slowing to less than the minimum safe speed when the autopilot is operating.

PL.2545 Pressurized systems elements.

Pressurized systems must withstand appropriate proof and burst pressures.

PL.2550 Equipment containing high-energy rotors.

Equipment containing high-energy rotors must be designed or installed to protect the occupants and aircraft from uncontained fragments.

SUBPART G—FLIGHTCREW INTERFACE AND OTHER INFORMATION

PL.2600 Flightcrew interface.

(a) The pilot compartment, its equipment, and its arrangement to include pilot view, must allow each pilot to perform their duties for all sources of lift and phases of flight and perform any maneuvers within the approved flight envelope of the aircraft, without excessive concentration, skill, alertness, or fatigue.

(b) The applicant must install flight, navigation, surveillance, and powerplant controls and displays, as needed, so qualified flightcrew can monitor and perform defined tasks associated with the intended functions of systems and equipment, without excessive concentration, skill, alertness, or fatigue. The system and equipment design must minimize flightcrew errors, which could result in additional hazards.

PL.2605 Installation and operation.

(a) Each item of installed equipment related to the flightcrew interface must be labelled, if applicable, as to it identification, function, or operating limitations, or any combination of these factors.

(b) There must be a discernible means of providing system operating parameters required to operate the aircraft, including warnings, cautions, and normal indications to the responsible crewmember.

(c) Information concerning an unsafe system operating condition must be provided in a timely manner to the crewmember responsible for taking corrective action. The information must be clear enough to avoid likely crewmember errors.

PL.2610 Instrument markings, control markings, and placards.

(a) Each aircraft must display in a conspicuous manner any placard and instrument marking necessary for operation.

(b) The design must clearly indicate the function of each cockpit control, other than primary flight controls.

(c) The applicant must include instrument marking and placard information in the Aircraft Flight Manual.

PL.2615 Flight, navigation, and powerplant instruments.

(a) Installed systems must provide the flightcrew member who sets or monitors parameters for the flight, navigation, and powerplant, the information necessary to do so during each phase of flight and source of lift. This information must—

(1) Be presented in a manner that the crewmember can monitor the parameter and determine trends, as needed, to operate the aircraft; and

(2) Include limitations, unless the limitations cannot be exceeded in all intended operations.

(b) Indication systems that integrate the display of flight or powerplant parameters to operate the aircraft, or are required by the operating rules of title 14, chapter I, must—

(1) Not inhibit the primary display of flight or powerplant parameters needed by any flightcrew member in any normal mode of operation; and

(2) In combination with other systems, be designed and installed so information essential for continued safe flight and landing will be available to the flightcrew in a timely manner after any single failure or probable combination of failures.

PL.2620 Aircraft flight manual.

The applicant must provide an Aircraft Flight Manual that must be delivered with each aircraft.

(a) The Aircraft Flight Manual must contain the following information—

(1) Aircraft operating limitations;

(2) Aircraft operating procedures;

(3) Performance information;

(4) Loading information; and

(5) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) The portions of the Aircraft Flight Manual containing the information specified in paragraphs (a)(1) through (a)(4) of this section must be approved by the FAA in a manner specified by the Administrator.

SUBPART H—AIRWORTHINESS CRITERIA FOR INSTRUMENT FLIGHT

PL.2701 General.

A powered-lift may not be type certificated for operation under the instrument flight rules (IFR) unless it meets the design and installation requirements contained in this subpart.

PL.2703 IFR flight envelope.

The applicant must determine an approved IFR flight envelope specifically for operations for flight into IFR conditions. If the approved IFR flight envelope differs from the approved flight envelope, then the applicant must use instrument flight speeds to comply with this subpart.

PL.2705 Definitions.

(a) V_{YI} means instrument climb speed, utilized instead of V_Y for compliance with the climb requirements for instrument flight, if different than climb speed as defined in PL.2120.

(b) V_{MINI} means instrument flight minimum speed, utilized in complying with minimum limit speed requirements for instrument flight, if different than minimum safe speed as defined in PL.2110.

(c) A practical flight envelope means a flight envelope where, in the event of flight control, propulsive, or stability augmentation malfunctions, compliance with controllability and maneuverability requirements must be demonstrated.

PL.2707 Trim.

It must be possible for the aircraft to stabilize by reduction forces or positions without pilot input. This must exist at all approved IFR airspeeds, power settings, and configurations appropriate to the type.

PL.2709 Flying and handling qualities.

PL.2145 must be reassessed for IFR approval and must ensure that—

(a) The aircraft exhibits static stability for operations for flight into instrument meteorological conditions that include the effects of atmospheric disturbances.

(b) The aircraft cannot exhibit any divergent stability characteristics in any axis.

(c) The showing must be primarily based on a positive control movement or forces, in addition to acceptable handling qualities by assessing task stability, pilot workload, acceptable cues, and pilot compensation during appropriate maneuvers and operations.

PL.2711 Stability augmentation.

For any failure or combination of failures not shown to be extremely improbable, the aircraft must be capable of continued safe flight and landing. In addition—

(a) The aircraft must remain safely controllable when the failure or malfunction occurs within the approved IFR flight envelope; and

(b) The overall flight characteristics must allow for prolonged flight without undue pilot effort. Additional unrelated probable failures affecting the control system must be considered. In addition—

(1) The controllability, maneuverability, and stability requirements in subpart B must be met throughout a practical flight envelope; and

(2) The flight control, trim, and flying qualities must not be reduced below that needed for continued safe flight and landing.

PL.2713 Equipment, systems, and installation.

The basic equipment and installation must comply with PL.2500, PL.2505, PL.2510, PL.2525 and PL.2615, with the following additions:

(a) Instrument systems and other systems essential for IFR flight that could be adversely affected by icing must be adequately protected when exposed to atmospheric icing conditions.

(b) For each instrument essential for instrument flight—

(1) The equipment, systems, and installations must be designed so that one display of the information essential for continued safe flight and landing will remain available to the flying pilot after any single failure or combination of failures that is not shown to be extremely improbable either—

(i) Without pilot action, or

(ii) With pilot action if the aircraft exhibits sufficient flying qualities under PL.2709.

(2) Instruments, systems, or equipment that are interconnected for a second pilot must be designed to ensure continued normal functioning of pilot and copilot instruments in the event of any malfunction not shown to be extremely improbable.

(3) For single-pilot configurations, instruments which require a static source must be provided with a means of selecting a calibrated alternate source.

PL.2715 Aircraft flight manual.

An Aircraft Flight Manual or Aircraft Flight Manual IFR Supplement must be provided and must contain—

(a) Limitations. The approved IFR flight envelope, the IFR flightcrew composition, the revised kinds of operation, and the steepest IFR precision approach gradient for which the powered-lift is approved;

(b) Procedures. Required information for proper operation of IFR systems and the recommended procedures in the event of stability augmentation or electrical system failures; and

(c) Performance. If V_{YI} differs from V_Y, climb performance at V_{YI} and with maximum continuous power throughout the ranges of weight, altitude, and temperature for which approval is requested.

SUBPART I—ELECTRIC ENGINE

PL.3305 Instruction manual for installing and operating the engine.

Each applicant must prepare and make available to the Administrator prior to the issuance of the type certificate, and to the owner at the time of delivery of the engine, approved instructions for installing and operating the engine. The instructions must include at least the following:

(a) Installation instructions.

(1) The location of engine mounting attachments, the method of attaching the engine to the aircraft, and the maximum allowable load for the mounting attachments and related structure.

(2) The location and description of engine connections to be attached to accessories, pipes, wires, cables, ducts, and cowling.

(3) An outline drawing of the engine including overall dimensions.

(4) A definition of the physical and functional interfaces with the aircraft and aircraft equipment, including the propeller when applicable.

(5) Where an engine system relies on components that are not part of the engine type design, the interface conditions and reliability requirements for those components upon which engine approval is based must be specified in the engine installation instructions directly or by reference to appropriate documentation.

(6) A list of the instruments necessary for control of the engine, including the overall limits of accuracy and transient response required of such instruments for control of the operation of the engine, must also be stated so that the suitability of the instruments as installed may be assessed.

(b) Operation instructions.

(1) The operating limitations established by the Administrator.

(2) The power or thrust ratings and procedures for correcting for nonstandard atmosphere.

(3) The recommended procedures, under normal and extreme ambient conditions for:

(i) Starting;

(ii) Operating on the ground; and

(iii) Operating during flight.

(4) For engines having one or more engine inoperative ratings or other contingency ratings, applicants must provide data on engine performance characteristics and variability to enable the aircraft manufacturer to establish aircraft power assurance procedures.

(5) A description of the primary and all alternate modes, and any back-up system, together with any associated limitations, of the engine control system and its interface with the aircraft systems, including the propeller when applicable.

(c) Safety analysis assumptions. The assumptions of the safety analysis as described in PL.3375(d) with respect to the reliability of safety devices, instrumentation, early warning devices, maintenance checks, and similar equipment or procedures that are outside the control of the engine manufacturer.

PL.3307 Engine ratings and operating limitations.

(a) Engine ratings and operating limitations are established by the Administrator and included in the type certificate data sheet specified in 14 CFR 21.41, including ratings and limitations based on the operating conditions and information specified in this section, as applicable, and any other information found necessary for safe operation of the engine.

(b) For electric engines, ratings and operating limits are established relating to the following:

(1) Shaft power, torque, rotational speed, and temperature for:

(i) Rated takeoff power;

(ii) Rated maximum continuous power; and

(ii) Rated maximum temporary power and associated time limit.

(2) Duty cycle and the rating at that duty cycle. The duty cycle must be declared in the type certificate data sheet.

(3) Cooling fluid grade or specification.

(4) Power-supply requirements.

(5) Any other ratings or limitations that are necessary for the safe operation of the engine.

(c) In determining the engine performance and operating limitations, the overall limits of accuracy of the engine control system, of the engine electrical systems, and of the necessary instrumentation as defined in PL.3305(a)(6) must be taken into account.

PL.3308 Selection of engine power and thrust ratings.

(a) Requested engine power and thrust ratings must be selected by the applicant.

(b) Each selected rating must be for the lowest power or thrust that all engines of the same type may be expected to produce under the conditions used to determine that rating.

PL.3315 Materials.

The suitability and durability of materials used in the engine must—

(a) Be established on the basis of experience or tests; and

(b) Conform to approved specifications (such as industry or military specifications) that ensure their having the strength and other properties assumed in the design data.

PL.3317 Fire protection.

(a) The design and construction of the engine and the materials used must minimize the probability of the occurrence and spread of fire during normal operation and failure conditions and must minimize the effect of such a fire.

(b) Except as provided in paragraph (c) of this section, each external line, fitting, and other component, which contains or conveys flammable fluid during normal engine operation, must be fire resistant or fireproof, as determined by the Administrator. Components must be shielded or located to safeguard against the ignition of leaking flammable fluid.

(c) A tank, which contains flammable fluids and any associated shut-off means and supports, which are part of and attached to the engine, must be fireproof either by construction or by protection unless damage by fire will not cause leakage or spillage of a hazardous quantity of flammable fluid. For an engine having an integral oil sump of less than 23.7 liters capacity, the oil sump need not be fireproof or enclosed by a fireproof shield.

(d) An engine component designed, constructed, and installed to act as a firewall must be:

(1) Fireproof;

(2) Constructed so that no hazardous quantity of air, fluid or flame can pass around or through the firewall; and,

(3) Protected against corrosion;

(e) In addition to the requirements of paragraphs (a) and (b) of this section, engine control system components that are located in a designated fire zone must be fire resistant or fireproof, as determined by the Administrator.

(f) Unintentional accumulation of hazardous quantities of flammable fluid within the engine must be prevented by draining and venting.

(g) Any components, modules, or equipment, which are susceptible to or are potential sources of static discharges or electrical fault currents must be designed and constructed to be properly grounded to the engine reference, to minimize the risk of ignition in external areas where flammable fluids or vapors could be present.

(h) High-voltage electrical wiring interconnect systems must be protected against arc faults that can lead to hazardous engine effects as defined in PL.3375(g)(2). Any non-protected electrical wiring interconnects must be analyzed to show that arc faults do not cause a hazardous engine effect.

PL.3319 Durability.

(a) The engine design and construction must minimize the development of an unsafe condition of the engine between maintenance intervals, overhaul periods, or mandatory actions described in the applicable ICA.

(b) Each component of the propeller blade pitch control system which is a part of the engine type design must meet the requirements of sections PL.3521, PL.3523, PL.3542 and PL.3543.

PL.3321 Engine cooling.

Engine design and construction must provide the necessary cooling under conditions in which the aircraft is expected to operate. If cooling is required to satisfy the safety analysis as described in PL.3375, the cooling system monitoring features and usage must be documented in the engine installation manual.

PL.3323 Engine mounting attachments and structure.

(a) The maximum allowable limit and ultimate loads for engine mounting attachments and related engine structure must be specified.

(b) The engine mounting attachments and related engine structure must be able to withstand—

(1) The specified limit loads without permanent deformation; and

(2) The specified ultimate loads without failure, but may exhibit permanent deformation.

PL.3325 Accessory attachments.

The engine must operate properly with the accessory drive and mounting attachments loaded. Each engine accessory drive and mounting attachment must include provisions for sealing to prevent contamination of, or unacceptable leakage from, the engine interior. A drive and mounting attachment requiring lubrication for external drive splines, or coupling by engine oil, must include provisions for sealing to prevent unacceptable loss of oil and to prevent contamination from sources outside the chamber enclosing the drive connection. The design of the engine must allow for the examination, adjustment, or removal of each accessory required for engine operation.

PL.3326 Engine electrical systems.

(a) Applicability. Any system or device that provides, uses, conditions, or distributes electrical power, and is part of the engine type design, must provide for the continued airworthiness of the engine and must maintain electric engine ratings.

(b) Electrical systems. The electrical system must ensure the safe generation and transmission of power, and electrical load shedding, and that the engine does not experience any unacceptable operating characteristics or exceed its operating limits.

(c) Electrical-power distribution.

(1) The engine electrical-power distribution system must be designed to provide the safe transfer of electrical energy throughout the electrical power plant. The system must be designed to provide electrical power so that the loss, malfunction, or interruption of the electrical power source will not result in a hazardous engine effect, as defined in PL.3375(g)(2).

(2) The system must be designed and maintained to withstand normal and abnormal conditions during all ground and flight operations.

(3) The system must provide mechanical or automatic means to mitigate a faulted electrical-energy generation or storage device from affecting the safe transmission of electric energy to the electric engine or detrimental engine affects in the intended aircraft application.

(d) Protection systems. The engine electrical system must be designed such that the loss, malfunction, interruption of the electrical power source, or power conditions that exceed design limits will not result in hazardous engine effects, as defined in PL.3375(g)(2).

(e) Electrical Power Characteristics. The applicant must identify and declare, in the engine installation manual, the characteristics of any electrical power supplied from—

(1) The aircraft to the engine electrical system, for starting and operating the engine, including transient and steady-state voltage limits, or

(2) The engine to the aircraft via energy regeneration, and any other characteristics necessary for safe operation of the engine.

(f) Environmental limits. Environmental limits that cannot adequately be substantiated by endurance demonstration, validated analysis, or a combination thereof must be demonstrated by the system and component tests in PL.3391.

(g) Electrical-system failures. The engine electrical system must—

(1) Have a maximum rate of loss of power control (LOPC) that is suitable for the intended aircraft application;

(2) When in the full-up configuration, be single fault tolerant, as determined by the Administrator, for electrical, electrically detectable, and electronic failures involving LOPC events;

(3) Not have any single failure that results in hazardous engine effects as defined in PL.3375(g)(2); and

(4) Ensure any electrical system failures or malfunctions that lead to local events in the intended aircraft application do not result in hazardous engine effects as defined in PL.3375(g)(2).

(h) System safety assessment. The applicant must perform a system safety assessment. This assessment must identify faults or failures that affect normal operation, together with the predicted frequency of occurrence of these faults or failures. The intended aircraft application must be taken into account to assure the assessment of the engine system safety is valid.

PL.3327 Overspeed.

(a) A rotor overspeed must not result in a burst, rotor growth, or damage that results in a hazardous engine effect, as defined in PL.3375(g)(2). Compliance with this paragraph must be shown by test, validated analysis, or a combination of both. Applicable assumed rotor speeds must be declared and justified.

(b) Rotors must possess sufficient strength with a margin to burst above approved operating conditions and above failure conditions leading to rotor overspeed. The margin to burst must be shown by test, validated analysis, or a combination thereof.

(c) The engine must not exceed the rotor-speed operational limitations that could affect rotor structural integrity.

PL.3328 Engine control systems.

(a) Applicability. These requirements apply to any system or device that is part of the engine type design that controls, limits, monitors, or protects engine operation and is necessary for the continued airworthiness of the engine.

(b) Engine control. The engine control system must ensure that the engine does not experience any unacceptable operating characteristics or exceed its operating limits, including in failure conditions where the fault or failure results in a change from one control mode to another, from one channel to another, or from the primary system to the back-up system, if applicable.

(c) Design assurance. The software and complex electronic hardware, including programmable logic devices, must be—

(1) Designed and developed using a structured and systematic approach that provides a level of assurance for the logic commensurate with the hazard associated with the failure or malfunction of the systems in which the devices are located; and

(2) Substantiated by a verification methodology acceptable to the Administrator.

(d) Validation. All functional aspects of the control system must be substantiated by test, analysis, or a combination thereof, to show that the engine control system performs the intended functions throughout the approved flight envelope.

(e) Environmental limits. Environmental limits that cannot be adequately substantiated by endurance demonstration, validated analysis, or a combination thereof must be demonstrated by the system and component tests in PL.3391.

(f) Engine control system failures. The engine control system must—

(1) Have a maximum rate of LOPC that is suitable for the intended aircraft application. The estimated LOPC rate must be specified in the engine installation manual;

(2) When in the full-up configuration, be single fault tolerant, as determined by the Administrator, for electrical, electrically detectable, and electronic failures involving LOPC events;

(3) Not have any single failure that results in hazardous engine effects as defined in PL.3375(g)(2); and

(4) Ensure failures or malfunctions that lead to local events in the aircraft do not result in hazardous engine effects as defined in PL.3375(g)(2) due to engine control system failures or malfunctions.

(g) System safety assessment. The applicant must perform a system safety assessment. This assessment must identify faults or failures that affect normal operation, together with the predicted frequency of occurrence of these faults or failures. The intended aircraft application must be taken into account to assure the assessment of the engine control system safety is valid. The rates of hazardous and major faults must be declared in the engine installation manual.

(h) Protection systems. The engine control devices and systems' design and function, together with engine instruments, operating instructions, and maintenance instructions, must ensure that engine operating limits that can lead to a hazard will not be exceeded in-service.

(i) Aircraft-supplied data. Any single failure leading to loss, interruption, or corruption of aircraft-supplied data (other than power command signals from the aircraft), or aircraft-supplied data shared between engine systems within a single engine or between fully independent engine systems, must—

(1) Not result in a hazardous engine effect, as defined in PL.3375(g)(2), for any engine installed on the aircraft; and

(2) Be able to be detected and accommodated by the control system.

(j) Engine control system electrical power.

(1) The engine control system must be designed such that the loss, malfunction, or interruption of the control system electrical power source will not result in a hazardous engine effect, unacceptable transmission of erroneous data, or continued engine operation in the absence of the control function. Hazardous engine effects are defined in PL.3375(g)(2). The engine control system must be capable of resuming normal operation when aircraft-supplied power returns to within the declared limits.

(2) The applicant must identify and declare, in the engine installation manual, the characteristics of any electrical power supplied from the aircraft to the engine control system, including transient and steady-state voltage limits, and any other characteristics necessary for safe operation of the engine.

PL.3329 Instrument connection.

(a) Unless it is constructed to prevent its connection to an incorrect instrument, each connection provided for powerplant instruments required by aircraft airworthiness regulations or necessary to insure operation of the engine in compliance with any engine limitation must be marked to identify it with its corresponding instrument.

(b) In addition, as part of the system safety assessment of PL.3328(g) and PL.3326(h), the applicant must assess the possibility and subsequent effect of incorrect fit of instruments, sensors, or connectors. Where practicable, the applicant must take design precautions to prevent incorrect configuration of the system.

(c) The applicant must make provision for the installation of instrumentation necessary to ensure operation in compliance with engine operating limitations. Where, in presenting the safety analysis, or complying with any other requirement, dependence is placed on instrumentation that is not otherwise mandatory in the assumed aircraft installation, then the applicant must specify this instrumentation in the engine installation instructions and declare it mandatory in the engine approval documentation.

(d) The applicant must provide instrumentation enabling the flight crew to monitor the functioning of the engine cooling system unless evidence shows that:

(1) Other existing instrumentation provides adequate warning of failure or impending failure;

(2) Failure of the cooling system would not lead to hazardous engine effects, as defined in PL.3375(g)(2), before detection; or

(3) The probability of failure of the cooling system is extremely remote.

(e) The sensors, together with associated wiring and signal conditioning, must be segregated, electrically and physically, to the extent necessary to ensure that the probability of a fault propagating from instrumentation and monitoring functions to control functions, or vice versa, is consistent with the failure effect of the fault.

PL.3362 Stress analysis.

(a) A mechanical and thermal stress analysis, as well as an analysis of the stress caused by electromagnetic forces, must show a sufficient design margin to prevent unacceptable operating characteristics and hazardous engine effects as defined in PL.3375(g)(2).

(b) Maximum stresses in the engine must be determined by test, validated analysis, or a combination thereof, and must be shown not to exceed minimum material properties.

PL.3363 Vibration.

The engine must be designed and constructed to function throughout its normal operating range of rotor speeds and engine output power, including defined exceedances, without inducing excessive stress in any of the engine parts because of vibration and without imparting excessive vibration forces to the aircraft structure.

PL.3364 Liquid and Gas Systems.

(a) Each system used for lubrication or cooling of engine components must be designed and constructed to function properly in all flight attitudes and atmospheric conditions in which the engine is expected to operate.

(b) If a system used for lubrication or cooling of engine components is not self-contained, the interfaces to that system must be defined in the engine installation manual.

(c) The applicant must establish by test, validated analysis, or a combination of both, that all static parts subject to significant pressure loads will not:

(1) Exhibit permanent distortion beyond serviceable limits or exhibit leakage that could create a hazardous condition when subjected to normal and maximum working pressure with margin.

(2) Exhibit fracture or burst when subjected to the greater of maximum possible pressures with margin.

(d) Compliance with paragraph (c) of this section must take into account:

(1) The operating temperature of the part;

(2) Any other significant static loads in addition to pressure loads;

(3) Minimum properties representative of both the material and the processes used in the construction of the part; and

(4) Any adverse physical geometry conditions allowed by the type design, such as minimum material and minimum radii.

(e) Approved coolants and lubricants must be listed in the engine installation manual.

PL.3370 Critical and life-limited parts.

(a) The applicant must show, by a safety analysis or means acceptable to the Administrator, whether rotating or moving components, bearings, shafts, static parts, and non-redundant mount components should be classified, designed, manufactured, and managed throughout their service life as critical or life-limited parts.

(1) *Critical part* means a part that must meet prescribed integrity specifications to avoid its primary failure, which is likely to result in a hazardous engine effect as defined in PL.3375(g)(2).

(2) *Life-limited parts* may include but are not limited to a rotor and major structural static part, the failure of which can result in a hazardous engine effect, as defined in PL.3375(g)(2), due to low-cycle fatigue (LCF) mechanism. A life limit is an operational limitation that specifies the maximum allowable number of flight cycles that a part can endure before the applicant must remove it from the engine.

(b) In establishing the integrity of each critical part or life-limited part, the applicant must provide to the Administrator the following three plans for approval:

(1) An engineering plan that contains the steps required to ensure each engine life-limited part is withdrawn from service at an approved life before hazardous engine effects can occur. In addition, the engineering plan must contain the steps to ensure each engine critical part is withdrawn from service before hazardous engine effects can occur. These steps include validated analysis, test, or service experience which ensures that the combination of loads, material properties, environmental influences and operating conditions, including the effects of other engine parts influencing these parameters, are sufficiently well known and predictable so that the operating limitations can be established and maintained for each engine life-limited and critical part. Applicants must perform appropriate damage tolerance assessments to address the potential for failure from material, manufacturing, and service induced anomalies within the approved life

of the part. Applicants must publish a list of the life-limited engine parts and the approved life for each part in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness as required by PL.1529.

(2) A manufacturing plan that identifies the specific manufacturing constraints necessary to consistently produce each engine life-limited and critical part with the attributes required by the engineering plan.

(3) A service management plan that defines in-service processes for maintenance and the limitations to repair for each engine life-limited and critical part that will maintain attributes consistent with those required by the engineering plan. These processes and limitations will become part of the Instructions for Continued Airworthiness.

PL.3371 Lubrication system.

(a) The lubrication system must be designed and constructed to function properly between scheduled maintenance intervals in all flight attitudes and atmospheric conditions in which the engine is expected to operate.

(b) The lubrication system must be designed to prevent contamination of the engine bearings and lubrication system components.

(c) The applicant must demonstrate by test, validated analysis, or a combination thereof, the unique lubrication attributes and functional capability of paragraphs (a) and (b) of this section.

PL.3373 Power response.

(a) The design and construction of the engine, including its control system, must enable an increase—

(1) From the minimum power setting to the highest rated power without detrimental engine effects;

(2) From the minimum obtainable power while in flight, and while on the ground, to the highest rated power within a time interval determined to be appropriate for the intended aircraft application; and

(3) From the minimum torque to the highest rated torque without detrimental engine effects in the intended aircraft application.

(b) The results of the increases in paragraphs (a)(1), (a)(2), and (a)(3) of this section must be included in the engine installation manual.

PL.3374 Continued rotation.

If the design allows any of the engine main rotating systems to continue to rotate after the engine is shut down while in-flight, this continued rotation must not result in any hazardous engine effects, as defined in PL.3375(g)(2).

PL.3375 Safety analysis.

(a)

(1) The applicant must analyze the engine, including the control system, to assess the likely consequences of all failures that can reasonably be expected to occur. This analysis will take into account, if applicable:

(i) Aircraft-level devices and procedures assumed to be associated with the intended aircraft application. Such assumptions must be stated in the analysis.

(ii) Consequential secondary failures and latent failures.

(iii) Multiple failures referred to in paragraph (d) of this section or that result in the hazardous engine effects defined in paragraph (g)(2) of this section.

(2) The applicant must summarize those failures that could result in major engine effects or hazardous engine effects, as defined in paragraph (g) of this section, and estimate the probability of occurrence of those effects. Any engine part the failure of which could reasonably result in a hazardous engine effect must be clearly identified in this summary.

(b) The applicant must comply with paragraphs (a)(1) and (a)(2) of this section using the failure definitions in paragraph (g) of this section.

(c) The primary failure of certain single elements cannot be sensibly estimated in numerical terms. If the failure of such elements is likely to result in hazardous engine effects, then compliance may be shown by reliance on the prescribed integrity requirements such as PL.3315, PL.3327, PL.3370, as applicable. These instances must be stated in the safety analysis.

(d) If reliance is placed on a safety system to prevent a failure from progressing to hazardous engine effects, the possibility of a safety system failure in combination with a basic engine failure must be included in the analysis. Such a safety system may include safety devices, instrumentation, early warning devices, maintenance checks, and other similar equipment or procedures. If items of a safety system are outside the control of the engine manufacturer, the assumptions of the safety analysis with respect to the reliability of these parts must be clearly stated in the analysis and identified in the installation instructions under PL.3305.

(e) If the safety analysis depends on one or more of the following items, those items must be identified in the analysis and appropriately substantiated.

(1) Maintenance actions being carried out at stated intervals. This includes the verification of the serviceability of items that could fail in a latent manner. When necessary to prevent hazardous engine effects, these maintenance actions and intervals must be published in the ICA required under PL.1529. Additionally, if errors in maintenance of the engine, including the control system, could lead to hazardous engine effects, the appropriate procedures must be included in the relevant engine manuals.

(2) Verification of the satisfactory functioning of safety or other devices at pre-flight or other stated periods. The details of this satisfactory functioning must be published in the appropriate manual.

(3) The provisions of specific instrumentation not otherwise required.

(4) Flight crew actions to be specified in the operating instructions established under PL.3305.

(f) The applicant must comply with paragraphs (d) and (e) of this section using the failure definitions in paragraph (g) of this section.

(g) Unless otherwise approved by the Administrator, the following definitions apply to the engine effects when showing compliance with these airworthiness criteria:

(1) A minor engine effect does not prohibit the engine from performing its intended functions in a manner consistent with (g)(1)(i) through (g)(1)(iii) of this section, and the engine complies with the operability requirements of PL.3373 and PL.3389, as appropriate.

(i) Enables selected values of relevant control parameters to be maintained and the engine kept within the approved operating limits over changing atmospheric conditions in the approved flight envelope;

(ii) Allows modulation of engine power or thrust with adequate sensitivity over the declared range of engine operating conditions; and

(iii) Does not create unacceptable power or thrust oscillation.

(2) The following effects will be regarded as hazardous engine effects:

(i) Non-containment of high-energy debris;

(ii) Concentration of toxic products in the engine bleed air intended for the cabin sufficient to incapacitate crew or passengers;

(iii) Significant thrust in the opposite direction to that commanded by the pilot;

(iv) Uncontrolled fire;

(v) Failure of the engine mount system leading to inadvertent engine separation;

(vi) Release of the propeller by the engine, if applicable;

(vii) Complete inability to shut the engine down;

(viii) Electrocution of the crew, passengers, operators, maintainers, or others; and

(ix) Blockage of cooling systems that could cause the engine effects described in paragraphs (g)(2)(i) through (g)(2)(viii) of this section.

(3) Any other engine effect is a major engine effect.

(h) The intended aircraft application must be taken into account when performing the safety analysis.

(i) The results of the safety analysis and the assumptions about the aircraft application used in the safety analysis must be documented in the engine installation manual.

PL.3377 Ingestion.

(a) Rain, ice, and hail ingestion must not result in an abnormal operation such as shutdown, power loss, erratic operation, or power oscillations throughout the engine operating range.

(b) Ingestion from other likely sources (birds, induction system ice, hailstones, foreign objects—ice slabs) must not result in hazardous engine effects, as defined in PL.3375(g)(2), or unacceptable power loss.

(c) If the design of the engine relies on features, attachments, or systems that the installer may supply, for the prevention of unacceptable power loss or hazardous engine effects as defined in PL.3375(g)(2) following potential ingestion, then the features, attachments, or systems must be documented in the engine installation manual.

PL.3383 Vibration demonstration.

Each engine design must undergo a vibration survey to establish that the vibration characteristics of those components subject to induced vibration are acceptable throughout the approved flight envelope and engine operating range for the specific installation configuration. The possible sources of the induced vibration that the survey must assess are mechanical, aerodynamic, acoustical, internally induced electromagnetic, installation induced effects that can affect the engine vibration characteristics, and likely environmental effects. This survey must be shown by test, validated analysis, or a combination thereof.

PL.3384 Overtorque.

When approval is sought for a transient maximum engine overtorque, the applicant must demonstrate by test, validated analysis, or a combination thereof, that the engine can continue operation after operating at the maximum engine overtorque condition without maintenance action. Upon conclusion of overtorque tests conducted to show compliance with this subpart, or any other tests that are conducted in combination with the overtorque test, each engine part or individual groups of components must meet the requirements of PL.3393.

PL.3385 Calibration assurance.

Each engine must be subjected to calibration tests to establish its power characteristics and the conditions both before and after the endurance and durability demonstrations specified in PL.3387 and PL.3390.

PL.3387 Endurance demonstration.

(a) The applicant must subject the engine to an endurance demonstration, acceptable to the Administrator, to demonstrate the engine's limit capabilities.

(b) The endurance demonstration must include increases and decreases of the engine's power settings, energy regeneration, and dwellings at the power settings or energy regeneration for sufficient durations that produce the extreme physical conditions the engine experiences at rated performance levels, operational limits, and at any other conditions or power settings that are required to verify the limit capabilities of the engine.

PL.3388 Temperature limit.

The engine design must demonstrate its capability to endure operation at its temperature limits plus an acceptable margin. The applicant must quantify and justify the margin to the Administrator. The demonstration must be repeated for all declared duty cycles and ratings, and operating environments, that would impact temperature limits.

PL.3389 Operation demonstration.

The engine design must demonstrate safe operating characteristics, including but not limited to power cycling, starting, acceleration, and overspeeding throughout the approved flight envelope and operating range. The declared engine operational characteristics must account for installation loads and effects.

PL.3390 Durability demonstration.

The engine must be subjected to a durability demonstration to show that each part of the engine has been designed and constructed to minimize any unsafe condition of the system between overhaul periods or between engine replacement intervals if the overhaul is not defined. This test must simulate the conditions in which the engine is expected to operate in service, including typical start-stop cycles, to establish when the initial maintenance is required.

PL.3391 System and component tests.

The applicant must show that systems and components that cannot be adequately substantiated in accordance with the endurance demonstration or other demonstrations will perform their intended functions in all declared environmental and operating conditions.

PL.3392 Rotor locking demonstration.

If shaft rotation is prevented by locking the rotor(s), the engine must demonstrate:

(a) Reliable rotor locking performance;

(b) Reliable unlocking performance; and

(c) That no hazardous engine effects, as specified in PL.3375(g)(2), will occur.

PL.3393 Teardown inspection.

(a) Teardown evaluation.

(1) After the endurance and durability demonstrations have been completed, the engine must be completely disassembled. Each engine component and lubricant must be eligible for continued operation in accordance with the information submitted for showing compliance with PL.1529.

(2) Each engine component having an adjustment setting and a functioning characteristic that can be established independent of installation on or in the engine must retain each setting and functioning characteristic within the established and recorded limits at the beginning of the endurance and durability demonstrations.

(b) Non-Teardown evaluation. If a teardown cannot be performed for all engine components in a non-destructive manner, then the inspection or replacement intervals for these components and lubricants must be established based on the endurance and durability demonstrations and must be documented in the ICA in accordance with PL.1529.

PL.3394 Containment.

The engine must be designed and constructed to protect against likely hazards from rotating components as follows:

(a) The design of the case surrounding rotating components must provide for the containment of the rotating components in the event of failure, unless the applicant shows that the margin to rotor burst precludes the possibility of a rotor burst.

(b) If the margin to burst shows the case must have containment features in the event of failure, the case must provide for the containment of the failed rotating components. The applicant must define by test, validated analysis, or a combination thereof, and document in the engine installation manual, the energy level, trajectory, and size of fragments released from damage caused by the main rotor failure, and that pass forward or aft of the surrounding case.

PL.3395 Operation with variable-pitch propeller.

The applicant must conduct functional demonstrations including feathering, negative torque, negative thrust, and reverse thrust operations, as applicable, with a representative propeller.

These demonstrations may be conducted in a manner acceptable to the Administrator as part of the endurance, durability, and operation demonstrations.

PL.3399 General conduct of tests.

(a) Maintenance of the engine may be made during the tests in accordance with the service and maintenance instructions submitted in compliance with PL.1529.

(b) The applicant must subject the engine or its parts to any additional tests that the Administrator finds necessary if—

(1) The frequency of engine service is excessive;

(2) The number of stops due to engine malfunction is excessive;

(3) Major engine repairs are needed; or

(4) Replacement of an engine part is found necessary during the tests or due to the teardown inspection findings.

(c) Upon completion of all demonstrations and testing specified in these airworthiness criteria, the engine and its components must be—

(1) Within serviceable limits;

(2) Safe for continued operation; and

(3) Capable of operating at declared ratings while remaining within limits.

SUBPART J—PROPELLER

PL.3503 Instructions for propeller installation and operation.

The applicant must provide instructions that are approved by the Administrator. Those approved instructions must contain:

(a) Instructions for installing the propeller, which:

(1) Include a description of the operational modes of the propeller control system and functional interface of the control system with the aircraft and engine systems;

(2) Specify the physical and functional interfaces with the aircraft, aircraft equipment and engine;

(3) Define the limiting conditions on the interfaces from paragraph (a)(2) of this section;

(4) List the limitations established under PL.3505;

(5) Define the hydraulic fluids approved for use with the propeller, including grade and specification, related operating pressure, and filtration levels; and

(6) State the assumptions made to comply with the requirements of these airworthiness criteria.

(b) Instructions for operating the propeller which must specify all procedures necessary for operating the propeller within the limitations of the propeller type design.

PL.3505 Propeller ratings and operating limitations.

Propeller ratings and operating limitations must be established by the applicant and approved by the Administrator, including ratings and limitations based on the operating conditions and information specified in this subpart, as applicable, and any other information found necessary for safe operation of the propeller.

PL.3507 Features and characteristics.

(a) The propeller may not have features or characteristics, revealed by any test or analysis or known to the applicant, that make it unsafe for the uses for which certification is requested.

(b) If a failure occurs during a certification test, the applicant must determine the cause and assess the effect on the airworthiness of the propeller. The applicant must make changes to the design and conduct additional tests that the Administrator finds necessary to establish the airworthiness of the propeller.

PL.3515 Safety analysis.

(a) The applicant must:

(1) Analyze the propeller system to assess the likely consequences of all failures that can reasonably be expected to occur. This analysis will take into account, if applicable:

(i) The propeller system when installed on the aircraft. When the analysis depends on representative components, assumed interfaces, or assumed installed conditions, the assumptions must be stated in the analysis.

(ii) Consequential secondary failures and dormant failures.

(iii) Multiple failures referred to in paragraph (d) of this section, or that result in the hazardous propeller effects defined in paragraph (g)(1) of this section.

(2) Summarize those failures that could result in major propeller effects or hazardous propeller effects defined in paragraph (g) of this section, and estimate the probability of occurrence of those effects.

(3) Show that hazardous propeller effects are not predicted to occur at a rate in excess of that defined as extremely remote (probability of 10^{-7} or less per propeller flight hour). Because the estimated probability for individual failures may be insufficiently precise to enable the applicant to assess the total rate for hazardous propeller effects, compliance may be shown by demonstrating that the probability of a hazardous propeller effect arising from an individual failure can be predicted to be not greater than 10^{-8} per propeller flight hour. In dealing with probabilities of this low order of magnitude, absolute proof is not possible, and reliance must be placed on engineering judgment and previous experience, combined with sound design and test philosophies.

(b) If significant doubt exists as to the effects of failures or likely combination of failures, the Administrator may require assumptions used in the analysis to be verified by test.

(c) The primary failures of certain single propeller elements (for example, blades) cannot be sensibly estimated in numerical terms. If the failure of such elements is likely to result in hazardous propeller effects, those elements must be identified as propeller critical parts. For propeller critical parts, the applicant must meet the prescribed integrity specifications of PL.3516. These instances must be stated in the safety analysis.

(d) If reliance is placed on a safety system to prevent a failure progressing to hazardous propeller effects, the possibility of a safety system failure, in combination with a basic propeller failure, must be included in the analysis. Such a safety system may include safety devices, instrumentation, early warning devices, maintenance checks, and other similar equipment or procedures.

(e) If the safety analysis depends on one or more of the following items, those items must be identified in the analysis and appropriately substantiated.

(1) Maintenance actions being carried out at stated intervals. This includes verifying that items that could fail in a latent manner are functioning properly. When necessary to prevent hazardous propeller effects, these maintenance actions and intervals must be published in the ICA required under PL.1529. Additionally, if errors in maintenance of the propeller system could lead to hazardous propeller effects, the appropriate maintenance procedures must be included in the relevant propeller manuals.

(2) Verification of the satisfactory functioning of safety or other devices at pre-flight or other stated periods. The details of this satisfactory functioning must be published in the appropriate manual.

(3) The provision of specific instrumentation not otherwise required. Such instrumentation must be published in the appropriate documentation.

(4) A fatigue assessment.

(f) If applicable, the safety analysis must include, but not be limited to, assessment of indicating equipment, manual and automatic controls, governors and propeller-control systems, synchrophasers, synchronizers, and propeller thrust reversal systems.

(g) Unless otherwise approved by the Administrator and stated in the safety analysis, the following failure definitions apply to compliance with these airworthiness criteria.

(1) The following are regarded as hazardous propeller effects:

(i) The development of excessive drag.

(ii) A significant thrust in the opposite direction to that commanded by the pilot.

(iii) The release of the propeller or any major portion of the propeller.

(iv) A failure that results in excessive unbalance.

(2) The following are regarded as major propeller effects for variable-pitch propellers:

(i) An inability to feather the propeller for feathering propellers.

(ii) An inability to change propeller pitch when commanded.

(iii) A significant uncommanded change in pitch.

(iv) A significant uncontrollable torque or speed fluctuation.

PL.3516 Propeller critical parts.

The integrity of each propeller critical part identified by the safety analysis required by PL.3515 must be established by:

(a) A defined engineering process for ensuring the integrity of the propeller critical part throughout its service life,

(b) A defined manufacturing process that identifies the requirements to consistently produce the propeller critical part as required by the engineering process, and

(c) A defined service-management process that identifies the continued airworthiness requirements of the propeller critical part as required by the engineering process.

PL.3517 Materials and manufacturing methods.
(a) The suitability and durability of materials used in the propeller must:
(1) Be established on the basis of experience, tests, or both.
(2) Account for environmental conditions expected in service.
(b) All materials and manufacturing methods must conform to specifications acceptable to the Administrator.
(c) The design values of properties of materials must be suitably related to the most adverse properties stated in the material specification for applicable conditions expected in service.

PL.3519 Durability.

Each part of the propeller must be designed and constructed to minimize the development of any unsafe condition of the propeller between overhaul periods.

PL.3521 Variable- and reversible-pitch propellers.

(a) No single failure or malfunction in the propeller system will result in unintended travel of the propeller blades to a position below the in-flight low-pitch position. The extent of any intended travel below the in-flight low-pitch position must be documented by the applicant in the appropriate manuals. Failure of structural elements need not be considered if the occurrence of such a failure is shown to be extremely remote under PL.3515.

(b) For propellers incorporating a method to select blade pitch below the in-flight low-pitch position, provisions must be made to sense and indicate to the flightcrew that the propeller blades are below that position by an amount defined in the installation instructions. The method for sensing and indicating the propeller blade pitch position must be such that its failure does not affect the control of the propeller.

PL.3522 Feathering propellers.

(a) Feathering propellers are intended to feather from all flight conditions, taking into account expected wear and leakage. Any feathering and unfeathering limitations must be documented in the appropriate manuals.

(b) Propeller pitch control systems that use engine oil to feather must incorporate a method to allow the propeller to feather if the engine oil system fails.

(c) Feathering propellers must be designed to be capable of unfeathering after the propeller system has stabilized to the minimum declared outside air temperature.

PL.3523 Propeller control system.

The requirements of this section apply to any system or component that controls, limits, or monitors propeller functions.

(a) The propeller control system must be designed, constructed and validated to show that:

(1) The propeller control system, operating in normal and alternative operating modes and in transition between operating modes, performs the functions defined by the applicant throughout the approved operating conditions and approved flight envelope.

(2) The propeller control system functionality is not adversely affected by the declared environmental conditions, including temperature, electromagnetic interference (EMI), high intensity radiated fields (HIRF), and lightning. The environmental limits to which the system has been satisfactorily validated must be documented in the appropriate propeller manuals.

(3) A method is provided to indicate that an operating mode change has occurred if flightcrew action is required. In such an event, operating instructions must be provided in the appropriate manuals.

(b) The propeller control system must be designed and constructed so that, in addition to compliance with PL.3515:

(1) No single failure results in a hazardous propeller effect;

(2) Local events in the intended aircraft installation will not result in hazardous propeller effects;

(3) The loss of normal propeller pitch control does not cause a hazardous propeller effect under the intended operating conditions; and

(4) The failure or corruption of data or signals shared across propellers does not cause a hazardous propeller effect.

(c) Electronic propeller-control-system embedded software must be designed and implemented by a method approved by the Administrator that is consistent with the criticality of the performed functions and that minimizes the existence of software errors.

(d) The propeller control system must be designed and constructed so that the failure or corruption of aircraft-supplied data does not result in hazardous propeller effects.

(e) The propeller control system must be designed and constructed so that the loss, interruption, or abnormal characteristic of aircraft-supplied electrical power does not result in hazardous propeller effects. The power quality requirements must be described in the appropriate manuals.

PL.3524 Strength.

The maximum stresses developed in the propeller may not exceed values acceptable to the Administrator considering the particular form of construction and the most severe operating conditions.

PL.3533 General.

(a) Each applicant must furnish test article(s) and suitable testing facilities, including equipment and competent personnel, and conduct the required tests in accordance with 14 CFR part 21.

(b) All automatic controls and safety systems must be in operation unless it is accepted by the Administrator as impossible or not required because of the nature of the test. If needed for substantiation, the applicant may test a different propeller configuration if this does not constitute a less severe test.

(c) Any systems or components that cannot be adequately substantiated by the applicant to the requirements of these airworthiness criteria are required to undergo additional tests or analysis to demonstrate that the systems or components are able to perform their intended functions in all declared environmental and operating conditions.

PL.3534 Inspections, adjustments, and repairs.

(a) Before and after conducting the tests prescribed in this part, the test article must be subjected to an inspection, and a record must be made of all the relevant parameters, calibrations and settings.

(b) During all tests, only servicing and minor repairs are permitted. If major repairs or part replacement is required, the Administrator must approve the repair or part replacement prior to implementation and may require additional testing. Any unscheduled repair or action on the test article must be recorded and reported.

PL.3535 Centrifugal load tests.

The applicant must demonstrate that a propeller complies with paragraphs (a), (b) and (c) of this section without evidence of failure, malfunction, or permanent deformation that would result in a major or hazardous propeller effect. When the propeller could be sensitive to environmental degradation in service, this must be considered.

(a) The hub, blade retention system, and counterweights must be tested for a period of one hour to a load equivalent to twice the maximum centrifugal load to which the propeller would be subjected during operation at the maximum rated rotational speed.

(b) Blade features associated with transitions to the retention system (for example, a composite blade bonded to a metallic retention) must be tested either during the test of paragraph (a) of this section or in a separate component test for a period of one hour to a load equivalent to twice the maximum centrifugal load to which the propeller would be subjected during operation at the maximum rated rotational speed.

(c) Components used with or attached to the propeller (for example, spinners, de-icing equipment, and blade erosion shields) must be subjected to a load equivalent to 159 percent of the maximum centrifugal load to which the component would be subjected during operation at the maximum rated rotational speed. This must be performed by either:

(1) Testing at the required load for a period of 30 minutes; or

(2) Analysis based on test.

PL.3536 Bird impact.

The applicant must demonstrate, by tests or analysis based on tests or experience on similar designs, that the propeller can withstand the impact of a 4-pound bird at the critical location(s) and critical flight condition(s) of the intended aircraft application without causing a major or hazardous propeller effect.

PL.3537 Fatigue limits and evaluation.

(a) Fatigue limits must be established by tests, or analysis based on tests, for propeller:

(1) Hubs.

(2) Blades.

(3) Blade retention components.

(4) Components which are affected by fatigue loads and which are shown under PL.3515 to have a fatigue failure mode leading to hazardous propeller effects.

(b) The fatigue limits must take into account:

(1) All known and reasonably foreseeable vibration and cyclic load patterns that are expected in service; and

(2) Expected service deterioration, variations in material properties, manufacturing variations, and environmental effects.

(c) A fatigue evaluation of the propeller must be conducted to show that hazardous propeller effects due to fatigue will be avoided throughout the intended operational life of the propeller on the intended aircraft by complying with PL.2400(c) of these airworthiness criteria.

PL.3538 Lightning strike.

The applicant must demonstrate, by tests, analysis based on tests, or experience on similar designs, that the propeller can withstand a lightning strike without causing a major or hazardous propeller effect. The limit to which the propeller has been qualified must be documented in the appropriate manuals.

PL.3539 Endurance test.

Endurance tests on the propeller system must be made on a representative engine in accordance with paragraph (a) or (b) of this section, as applicable, without evidence of failure or malfunction.

(a) Fixed-pitch and ground adjustable-pitch propellers must be subjected to one of the following tests:

(1) A 50-hour flight test in level flight or in climb. The propeller must be operated at takeoff power and rated rotational speed during at least five hours of this flight test, and at not less than 90 percent of the rated rotational speed for the remainder of the 50 hours.

(2) A 50-hour ground test at takeoff power and rated rotational speed.

(b) Variable-pitch propellers must be subjected to one of the following tests:

(1) A 110-hour endurance test that must include the following conditions:

(i) Five hours at takeoff power and rotational speed and thirty 10-minute cycles composed of:

(A) Acceleration from idle,

(B) Five minutes at takeoff power and rotational speed,

(C) Deceleration, and

(D) Five minutes at idle.

(ii) Fifty hours at maximum continuous power and rotational speed,

(iii) Fifty hours, consisting of ten 5-hour cycles composed of:

(A) Five accelerations and decelerations between idle and takeoff power and rotational speed,

(B) Four and one half hours at approximately even incremental conditions from idle up to, but not including, maximum continuous power and rotational speed, and

(C) Thirty minutes at idle.

(2) The operation of the propeller throughout the engine endurance tests prescribed in these airworthiness criteria.

(c) For propellers having higher ratings or rotational speeds than takeoff power and rated rotational speed, those ratings and speeds must be used in the tests required by paragraph (a) or (b) of this section.

(d) If a propeller can be tilted from vertical to horizontal operation and vice versa, the transitions must be performed as part of the tests required by paragraph (a) or (b) of this section.

PL.3540 Functional test.

The variable-pitch propeller system must be subjected to the applicable functional tests of this section. The same propeller system used in the endurance test of PL.3539 must be used in the functional tests and must be driven by a representative engine on a test stand or on the aircraft. The propeller must complete these tests without evidence of failure or malfunction. This test may be combined with the endurance test for accumulation of cycles.

(a) Governing and reversible-pitch propellers. Fifteen hundred complete cycles must be made across the range of forward pitch and rotational speed. In addition, 200 complete cycles of control must be made from lowest normal pitch to maximum reverse pitch. During each cycle, the propeller must run for 30 seconds at the maximum power and rotational speed selected by the applicant for maximum reverse pitch.

(b) Feathering propellers. Fifty cycles of feather and unfeather operation must be made.

PL.3541 Overspeed and overtorque.

(a) When the applicant seeks approval of a transient maximum propeller overspeed, the applicant must demonstrate that the propeller is capable of further operation without maintenance action at the maximum propeller overspeed condition. This may be accomplished by:

(1) Performance of 20 runs, each of 30 seconds duration, at the maximum propeller overspeed condition; or

(2) Analysis based on test or service experience.

(b) When the applicant seeks approval of a transient maximum propeller overtorque, the applicant must demonstrate that the propeller is capable of further operation without maintenance action at the maximum propeller overtorque condition. This may be accomplished by performance of 20 runs, each of 30 seconds duration, at the maximum propeller overtorque condition.

PL.3542 Components of the propeller control system.

The applicant must demonstrate by tests, analysis based on tests, or service experience on similar components, that each propeller blade pitch control system component, including governors, pitch change assemblies, pitch locks, mechanical stops, and feathering system components, can withstand cyclic operation that simulates the normal load and pitch change travel to which the component would be subjected during the initially declared overhaul period or during a minimum of 1,000 hours of typical operation in service.

PL.3543 Propeller hydraulic components.

Applicants must show by test, validated analysis, or both, that propeller components that contain hydraulic pressure and whose structural failure or leakage from a structural failure could cause a hazardous propeller effect demonstrate structural integrity by:

(a) A proof pressure test to 1.5 times the maximum operating pressure for one minute without permanent deformation or leakage that would prevent performance of the intended function.

(b) A burst pressure test to 2.0 times the maximum operating pressure for one minute without failure. Leakage is permitted and seals may be excluded from the test.

SUBPART K—INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

PL.4101 General.

(a) This subpart specifies requirements for the preparation of Instructions for Continued Airworthiness as required by PL.1529.

(b) The Instructions for Continued Airworthiness for each aircraft must include the Instructions for Continued Airworthiness for each engine and propeller (hereinafter designated “products”), for each appliance required by 14 CFR chapter I, and any required information relating to the interface of those appliances and products with the aircraft. If Instructions for Continued Airworthiness are not supplied by the manufacturer of an appliance or product installed in the aircraft, the Instructions for Continued Airworthiness for the aircraft must include the information essential to the continued airworthiness of the aircraft.

(c) The applicant must submit to the FAA a program to show how changes to the Instructions for Continued Airworthiness made by the applicant or by the manufacturers of products and appliances installed in the aircraft will be distributed.

PL.4102 Format.

(a) The Instructions for Continued Airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

PL.4103 Content.

The contents of the manual or manuals must be prepared in the English language. The Instructions for Continued Airworthiness must contain the following manuals or sections and information:

(a) Aircraft maintenance manual or section.

(1) Introduction information that includes an explanation of the aircraft's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A description of the aircraft and its systems and installations including its engines, propellers, and appliances.

(3) Basic control and operation information describing how the aircraft components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of

access panels for inspection and servicing, locations of lubrication points, lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and leveling information.

(b) Maintenance Instructions.

(1) Scheduling information for each part of the aircraft and its engines, auxiliary power units, propellers, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if the applicant shows that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross reference to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the aircraft.

(2) Troubleshooting information describing probable malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the center of gravity, lifting and shoring, and storage limitations.

(c) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(d) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified by the applicant.

(e) Information needed to apply protective treatments to the structure after inspection.

(f) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(g) A list of special tools needed.

PL.4104 Airworthiness limitations section.

The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure required for type certification. If the Instructions for Continued Airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads “The Airworthiness Limitations section is FAA approved and specifies inspections and other maintenance required under §§ 43.16 and 91.403 of the Federal Aviation Regulations unless an alternative program has been FAA approved.”

SUBPART L—INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (ELECTRIC ENGINE)

PL.4301 General.

(a) This subpart specifies requirements for the preparation of ICA for the engines as required by PL.1529.

(b) The ICA for the engine must include the ICA for all engine parts.

(c) The applicant must submit to the FAA a program to show how the applicant's changes to the ICA will be distributed, if applicable.

PL.4302 Format.

(a) The Instructions for Continued Airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

PL.4303 Content.

The contents of the manual or manuals must be prepared in the English language. The Instructions for Continued Airworthiness must contain the following manuals or sections, as appropriate, and information:

(a) Engine Maintenance Manual or Section.

(1) Introduction information that includes an explanation of the engine's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A detailed description of the engine and its components, systems, and installations.

(3) Installation instructions, including proper procedures for uncrating, deinhibiting, acceptance checking, lifting, and attaching accessories, with any necessary checks.

(4) Basic control and operating information describing how the engine components, systems, and installations operate, and information describing the methods of starting, running, testing, and stopping the engine and its parts including any special procedures and limitations that apply.

(5) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, locations of lubrication points, lubricants to be used, and equipment required for servicing.

(6) Scheduling information for each part of the engine that provides the recommended periods at which it should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection the applicable wear tolerances, and work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if the applicant shows that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the engine.

(7) Troubleshooting information describing probable malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

(8) Information describing the order and method of removing the engine and its parts and replacing parts, with any necessary precautions to be taken. Instructions for proper ground handling, crating, and shipping must also be included.

(9) A list of the tools and equipment necessary for maintenance and directions as to their method of use.

(b) Engine Overhaul Manual or Section.

(1) Disassembly information including the order and method of disassembly for overhaul.

(2) Cleaning and inspection instructions that cover the materials and apparatus to be used and methods and precautions to be taken during overhaul. Methods of overhaul inspection must also be included.

(3) Details of all fits and clearances relevant to overhaul.

(4) Details of repair methods for worn or otherwise substandard parts and components along with the information necessary to determine when replacement is necessary.

(5) The order and method of assembly at overhaul.

(6) Instructions for testing after overhaul.

(7) Instructions for storage preparation, including any storage limits.

(8) A list of tools needed for overhaul.

PL.4304 Airworthiness limitations section.

The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the manual.

(a) For all engines:

(1) The Airworthiness Limitations section must set forth each mandatory replacement time, inspection interval, and related procedure required for type certification. If the Instructions for Continued Airworthiness consist of multiple documents, the section required under this paragraph must be included in the principal manual.

(2) This section must contain a legible statement in a prominent location that reads: “The Airworthiness Limitations section is FAA approved and specifies maintenance required under §§ 43.16 and 91.403 of the Federal Aviation Regulations unless an alternative program has been FAA approved.”

SUBPART M—INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (PROPELLERS)

PL.4501 General.

(a) This subpart specifies requirements for the preparation of ICA for the propellers as required by PL.1529.

(b) The ICA for the propeller must include the ICA for all propeller parts.

(c) The applicant must submit to the FAA a program to show how changes to the ICA made by the applicant or by the manufacturers of propeller parts will be distributed, if applicable.

PL.4502 Format.

(a) The Instructions for Continued Airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

PL.4503 Content.

The contents of the manual must be prepared in the English language. The Instructions for Continued Airworthiness must contain the following sections and information:

(a) Propeller Maintenance Section.

(1) Introduction information that includes an explanation of the propeller's features and data to the extent necessary for maintenance or preventive maintenance.

(2) A detailed description of the propeller and its systems and installations.

(3) Basic control and operation information describing how the propeller components and systems are controlled and how they operate, including any special procedures that apply.

(4) Instructions for uncrating, acceptance checking, lifting, and installing the propeller.

(5) Instructions for propeller operational checks.

(6) Scheduling information for each part of the propeller that provides the recommended periods at which it should be cleaned, adjusted, and tested, the applicable wear tolerances, and the degree of work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if it shows that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross-references to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the propeller.

(7) Troubleshooting information describing probable malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

(8) Information describing the order and method of removing and replacing propeller parts with any necessary precautions to be taken.

(9) A list of the special tools needed for maintenance other than for overhauls.

(b) Propeller Overhaul Section.

(1) Disassembly information including the order and method of disassembly for overhaul.

(2) Cleaning and inspection instructions that cover the materials and apparatus to be used and methods and precautions to be taken during overhaul. Methods of overhaul inspection must also be included.

(3) Details of all fits and clearances relevant to overhaul.

(4) Details of repair methods for worn or otherwise substandard parts and components along with information necessary to determine when replacement is necessary.

(5) The order and method of assembly at overhaul.

(6) Instructions for testing after overhaul.

(7) Instructions for storage preparation including any storage limits.

(8) A list of tools needed for overhaul.

PL.4504 Airworthiness limitations section.

The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, inspection interval, and related procedure required for type certification. This section must contain a legible statement in a prominent location that reads: “The Airworthiness Limitations section is FAA approved and specifies maintenance required under §§ 43.16 and 91.403 of the Federal Aviation Regulations unless an alternative program has been FAA approved.”

OMB Control Number: 2120-0746
Expiration Date: 11/30/2024

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by (1) emailing this form to (9-AWA-AVS.AIR.DMO@faa.gov or (2) faxing it to the attention of the LOB/SO (202) 267-1813.

Subject: AC 21.17-4, Type Certification – Powered Lift Date: _______________

Please mark all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _______ on page _______.

☐ Recommend paragraph _______ on page _______ be changed as follows:
(attach separate sheet if necessary)

☐ In a future change to this order, please include coverage on the following subject:
(briefly describe what you want added.)

☐ Other comments:

☐ I would like to discuss the above. Please contact me.

Submitted by: ___________________________________ Date: __________________

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